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ROYAL

Geological Society of Cornwall.

TWENTY-EIGHTH

ANNUAL REPORT

OF THE COUNCIL,

WITH

THE PRESIDENT'S ADDRESS,

AND

PAPERS AND NOTICES

READ TO THE SOCIETY.

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1841.

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PRESIDENT'S ADDRESS.

HOWEVER interesting may be the retrospect which shows the advance of geological science in this county, there are other recollections which we are also bound to entertain, more melancholy in their impression, but, at the same time, involving a sacred duty which we owe to those whose course is finished, but who in their lifetime were benefactors to this society in particular. Amongst those most prominent stands the name of Sir Humphrey Davy. It is true that his loss is not of recent occurrence; but as the subject of his career has been lately taken up anew, and it is in comtemplation to erect a monument to his fame, which shall speak to the eye as the records of science speak to the understanding, I have thought it right to explain to you, and through you to the Cornish public, the steps which have been taken to do honour to the memory of a man who has done so much honour to his own native county. During the sitting of the British Association at Plymouth, a few gentlemen met together to consult on the means by which this object might be accomplished. It was thought desirable that the movement should commence in that assembly of men of science brought from all parts of the empire; thus to give the undertaking a general rather than a local aspect, and to show that his character, as it belonged to the country at large, so it was acknowledged and received as a benefit to the whole community. In that early stage, no more could be done than to take down the names of such as were willing to lend their aid, and to appoint two honorary secretaries, whose duty it would be to make known the object in view, to collect subscriptions, and, at a proper time, to convene an assembly of those interested, to whom they might make a report of their progress. It is intended that this meeting should take place in the course of the ensuing spring, and in London. The secretaries appointed were Mr. Hoblyn and Mr. Winsor. From the latter I have received two letters, in

one of which he tells me that they are about to circulate lithographed notices of what passed at Plymouth, together with the names of the subscribers then and subsequently obtained. But the undertaking has not yet met with the full amount of support which was anticipated, principally, Mr. Winsor says, on account of an objection to the erection of the monument in Cornwall, where so few, except residents, will have an opportunity of seeing it. Under these circumstances, it appears probable that the undertaking will drop, unless taken up warmly by this county and neighbourhood. If we can show that we are willing to make an effort on our part, perhaps auxiliary contributions may be drawn from a distance; but it appears from the tone of Mr. Winsor's letters, and the discouragement which he has felt, that the public are not inclined to look with favour on the project as it is now offered to them. I would therefore venture to recommend, either that a subscription list be immediately opened amongst ourselves, or that some other means be taken, by the appointment of a committee or otherwise, to ascertain the willingness of the county to lay the foundation of a subscription, to which others at a distance may be then very properly asked to contribute.

Since our last meeting, the science and literature of the county generally, and the geological society in particular, have met with a severe loss by the death of one of its earliest members and most copious contributors, Mr. Hawkins, of Trewithen, and Bignor Park. From the first commencement of the society, his papers have formed a valuable part of our transactions; and I have reason to believe that his contributions would have continued to be as frequent as heretofore, had the publication of our volumes been more regular, and kept pace with the rapid progress of a science which from year to year has advanced, and is advancing through spaces before untrodden, and amongst prospects perpetually enlarging. Mr. Hawkins's papers in our transactions are nineteen in number, and they display in strong colours the varied stores of his mind, derived from the lights of history and science, and from a close attention to the practical and economical bearing of geology on the great interests of his native county. Mr. Hawkins's fame as a scientific man would have stood even higher than it does, had his innate modesty allowed him to publish to the world his facts

and views at the periods when he discovered or formed them; but, by reason of the delay thus occasioned, many things were subsequently brought forward by others, of which the credit really belonged to him. The objection which he and some others have felt to the tardy publication of our transactions, has led the council to recommend to the society the adoption of a plan somewhat differing from that hitherto pursued, whereby to secure the prompt distribution of any valuable matter which may from time to time be brought before us. The society has likewise to lament the death of Mr. H. P. Tremenheere, who, although not a scientific man, has from the beginning supported the society, and felt a strong interest in its success. To Mr. Benjamin Sampson, whose demise also occurred during the past year, we owe the first document (a plan and section of a mine), which was sent to the society after its establishment.

The plan to which I have alluded is as follows: Instead of reserving all the communications until they would fill a volume of respectable size, as has been hitherto done, it is proposed that in future our publications should be in yearly parts or *fasciculi*, to be delivered shortly after the annual meetings, and to contain the actual record of the events and transactions of the year then closed. These may be bound when convenient, and still be made uniform with the valuable publications which have already issued from the society. It may (and probably would) become necessary to publish occasionally a supplemental and entire volume whenever we become possessed of a complete treatise, such as that of Dr. Boase, and the report of Mr. Henwood, which is now in course of printing; but highly important as such treatises are, it may be inconvenient to delay the communication of other interesting matter on their account only, and thus leave the county to suppose that the Geological Society is inactive.

The Council have imagined that as the science of geology tends to pour its streams over the being and happiness of that important class, the practical miners of the county, so they might hope to draw from that class treasures of practical observation, to be ripened in their hands into science. With this view they have accepted the offer which I have made of a premium of £5, to be distributed

in small sums to working miners, who shall report to the society any unusual occurrences which have come practically under their observation. The object of this premium is to place the actual miner in immediate relation with the society, to give him an interest in its proceedings, and to awaken in his mind an attention to those anomalies which frequently present themselves in his pursuit, the scientific value of which may be by no means heeded or understood by him. To him they may be only strange appearances, or at best, objects of admiration and curiosity; but there may still be truths of great importance concealed under such apparent departures from the ordinary course of nature—truths which may have a direct tendency to flow back on the miner himself through the channels of science. The value of such knowledge is not for us alone. The constant supply of facts, if we should thus succeed in obtaining it, drawn from sources almost exclusively in possession of this county, and brought to light by this society, will bring us into closer connection with the Geological Society of London, and with other societies, of which the promotion of geological science is one of the principal objects, and turn their attention with greatly increased interest to our proceedings and publications. It will, of course, be left to the Council to determine the form in which the premium which I have offered shall be rendered available for its objects; but it has occurred to me to suggest that the present meeting should appoint two or three gentlemen as a committee of award, and that to them should be sent any communications having a claim to the premium. I think they might refer each notice separately to some one member of the society at large, who might not only give his opinion of the value of the fact reported, but make such remarks on it as may occur to himself. Thus a constantly increasing current may be set in motion, bearing with it all the freshness of discovery, combined with the matured science of some of our more instructed members. If this plan should succeed, as I hope it will ultimately succeed, the premium which I have offered will be soon exhausted; and it is for the society to determine whether they will place at the disposal of the Council a small sum, to be applied, if necessary, in supplying any deficiency which may occur.

The necessity of providing space to receive our constantly increasing collections again painfully presses on us; and is rendered more urgent by the prospect of a large addition to our museum from the Cornish organic fossils, which are now found to be abundant. Till lately the existence of such fossils was either absolutely denied, or very sparingly admitted; and we were supposed to be almost entirely without that key to the knowledge of our strata. Borlase describes none which may not be considered either as accidental forms of mundic, or recent concretions on the shores of our harbours, containing the exuviæ of none but existing species of shell fish. The mode in which he accounts for the absence of organic remains in Cornwall is characteristic of the state of knowledge in his time, and so far historically interesting. He seems to have entertained an idea that no fossiliferous beds could possibly have existed previous to the Noahchian deluge; and that it is because the waters of that deluge happened to contain in some other places more of what he calls the "suspended spar" in which these fossils were to be imbedded; petrifactions found elsewhere are wanting here. Geology has made rapid strides since his day; but it would be unjust to Borlase not to admit that his sober views, on many points, place him at least as much in advance of those who preceded him by about an equal interval to that by which he has preceded us, as he has been left behind by his successors. Thus we find, that about eighty years prior to Borlase, Sir John Pettus, in his Fodinæ Regales, reasoned in the following terms on the cause of the inequalities of the earth's surface: "When God breathed upon the waters, it was a petrifying breath, and such waters as were quiet became plains, the boisterous waters becoming hills according to the proportion of the billows." But to return to the matter of Cornish fossils. I cannot find, in the four volumes of our transactions already published, any paper on the subject; nor, with the exception of a note quite at the end of Dr. Boase's treatise (in which he retracts his denial of the existence of fossil remains in Cornwall, with respect to one locality only, Tintagel), is there the description of a single shell or coralline, or any reference to its existence, much less any endeavour to make use of it to identify our strata. Mr. De la Beche has, however, shown how

abundant they are in the calcareous beds and slates which are associated with the great Grauwacke formation of the county; and how important it is to acquire a knowledge of their localities and species, that a true judgment may be formed as to the character of many of our rocks. Mr. Peach, with an assiduity and talent which do him the greatest credit, has applied his little leisure, and availed himself of the opportunities afforded him, in the execution of his duties as a riding officer, to study and collect the fossils of his district, and has made great additions to our knowledge of these ancient records. I understand that he has sent a large collection of them to the museum of this society, but I have not yet seen them; nor do I know whether the great difficulty which we labour under in finding space to contain our treasures has not made it impossible to render them accessible.

When at Plymouth, at the meeting of the British Association, I heard with great pleasure the commendations bestowed by Professor Phillips on Mr. Peach, who, he said, had brought to light many new forms of those ancient remains with which he was till then totally unacquainted. So great had been the additions made by Mr. Peach and others to the catalogue of fossils of the older strata, that he intended shortly to prepare a supplement to his work (just published) on Palæozoic Fossils; that is, on the records of animal organization in its earliest forms. A copy of the part already published is on the table, and I beg leave to present it to the society. Connected with this subject is a large specimen now before you, brought from the Falkland Islands by Commodore Sullivan, in whose name I request that it may find a place in your museum. The rock itself corresponds very exactly with some specimens in your cabinet upstairs from the neighbourhood of the Malvern Hills, and the fossils contained in it are, I believe, of the same geological date. Some years ago, when I sent these specimens to the society, I supposed the rock in which the fossils are imbedded to form part of the old red sandstone, but Mr. Murchison's recent speculations have brought to light distinctions which were not then perceived, and this portion of the Malvern district is now included amongst his lower Silurian beds. Specimens from the Falkland Islands have also been submitted to Mr.

Charles Darwin, and referred by him to the lower part of the Silurian system. The fossil which greatly prevails in the specimen before you was found by Professor Phillips at South Petherwin, in the eastern part of the county. Its name is Spirifera calcarata, and it is figured No. 128 of his Palæozoic Fossils.

When at Liverpool, during the meeting of the Agricultural Association, I heard that a bed of the new red sandstone had been opened in a quarry, near Warrington, containing innumerable traces of the footsteps of that extraordinary animal, the Cheirotherium. A gentleman resident in that town has been kind enough to procure for me specimens, which I now present to the society, together with casts of some of the same fossils in the Museum of the Natural History Society of Liverpool. These footsteps were, I believe, first discovered near Dumfries; but Dr. Buckland, in his Bridgewater Treatise, mentions that similar traces had been also found in Saxony, and that the animal, whose passage over the soft sand they record, had obtained the provisional name of Cheirotherium. He says also that some fragments of bones were found in the same quarries, but, unfortunately, destroyed; so that nothing remained to guide the comparative anatomist as to the nature of the animal, except the print of his foot. Since Dr. Buckland wrote, the mystery which attached to this, the earliest quadruped of which geology has discovered any trace, has been in some measure removed by the researches of Professor Owen. That excellent man, of whose talents it would be presumption in me to utter one word of praise, has lately had under examination the bones of an animal evidently connected with these footsteps. Its physiology appears to have been most extraordinary; combining the characteristics of the Batrachian and Saurian families; but, like many of the reptiles of the earlier period, this great lizard frog, if frog it was, far exceeded in size any type of the same order now existing, and probably attained the length of five feet. The structure of the animal is most anomalous throughout; and formed the subject of a paper read at the Geological Society of London, in the course of this season, and was again brought before the public, at the British Association at Plymouth, in a Report on the Fossil Reptiles of England, by Pro-

fessor Owen. This report excited the greatest interest at the geological section, and I am happy to say that £250 was voted for its publication in a form separate and distinct from the general report of the meeting. It will thus become accessible to all, and will contain plates which could hardly be admitted into the periodical publications of the association. Before I quit this subject, I may add that Mr. Cunningham, in his letter of advice respecting the fossils and casts which he has sent, informs us that he has discovered, in the same bed which the Cheirotherium seems to have traversed, remains of a gigantic fucus, 26 feet long and 7 or 8 feet broad.

There remains but one topic on which I will trouble the meeting with any further observations. There is on the table a box containing models, by Mr. Sopwith, of certain portions of the coal district in the neighbourhood of Newcastle. At first sight these models may appear as toys fit only to amuse; but they are far otherwise. They are meant to expose, and actually do expose, to the eye, the operations of those two causes, to which, in great measure, may be referred the present configuration of the earth's surface, and subjacent strata—dislocation and denudation; and are faithful representations, according to a given scale, of certain portions of the Newcastle district, with the geological facts there really existing. It is true that these models exhibit only incidents belonging to a country containing coal, of which we have none. Still the subject is general. To the student in geology, a knowledge of the coal formation is quite necessary; and even to the Cornish geologist, studying a different and older country, the lessons there taught are by no means uninstructive. Those great and general operations of nature, which are often with us spread over a vast surface, and are with difficulty combined into an intelligible hypothesis, are, amongst the coal measures, displayed on a scale much more easily read and comprehended; and this, because in the coal formation the strata are thinner and more readily distinguished. The faults and heaves often lie within a small compass, and the denudations are sensibly portrayed by the outcrop of strata, which cannot be mistaken. In fact, the coal formation is to the geologist what the satellites of Jupiter are to the astronomer—an example of general laws compendiously set forth, which in one case operate over large countries, and in the other over immense orbits and through lengthened periods of time.

THE TWENTY-EIGHTH ANNUAL REPORT OF THE COUNCIL.

ALTHOUGH the progress of the society during the past year has been unaccompanied by any of the great steps of advancement which have marked some of the preceding epochs of its existence, yet the Council have the satisfaction of reporting that the accessions to the collections have been of considerable extent.

It is a subject of regret that the contributions of our intelligent mine agents and miners, both to the Society's museum and to its transactions, have been unsually few. With a view to their increase, the liberality of the President, of E. W. W. Pendarves, Esq., M.P., and of William T. Praed, Esq., M.P., has placed at the disposal of the Council a sum to be distributed in premiums to such practical miners as may communicate to the Society during the ensuing year descriptions of any new, uncommon, or important facts which may occur in the course of their pursuits, attested by the agents of the mines in which they may be discovered, and which the Council suggest may be augmented from the Society's funds if the contributions shall appear worthy of it, and if accompanied by illustrative specimens.

The labours of Mr. Phillips, under the sanction of the Lords of the Treasury, have completed the description of the Cornish organic remains known at the time of his publication; and as, through the donations of Mr. McLauchlan, Mr. Garby, and, beyond all, Mr. Peach, the museum contains a large collection of those recently discovered, as well as some found twelve years ago by the Curator, it will now be easy to place them in stratigraphical order. Beside the donations in other years, Mr. Peach has now laid before the society a curious collection of organic forms which were yet unknown to us, accompanied by figures and descriptions. But the Council regret that the fossil geology of Cornwall is about to suffer by the removal of Mr. Peach to another part of the kingdom.

Mr. Gesner, the Government Geologist of Nova Scotia and New

Brunswick, has during the year contributed to the museum a valuable and interesting collection of minerals from the British North American Provinces; and Mr. Henwood has presented a series from the rock formations of all the British Colonies in that part of the world, and from most of the Northern States of the Union, which have supplied proofs of the existence of an extensive Silurian system in the state of New York, and probably also in New Brunswick; those of the fossils which are new to British geologists will be described to the Geological Society of London by that accomplished and indefatigable geologist, Mr. Lonsdale.

A series of the metalliferous deposits of Ireland and of the Channel Islands now renders nearly complete the Society's collection from the copper formations of the United Kingdom, on which Mr. Henwood has been long engaged.

These, with the other yet unplaced stores which the society possesses, will more than fill every accommodation the present rooms afford; and it appears almost superfluous to commence an arrangement which another year's labour will require to be again disturbed. The Council therefore feel it their duty again to submit to the society the imperative necessity for additional space. They also desire to point out to the society and to the public that whilst this, the oldest scientific institution in the West of England, is without a habitation of its own, every one of the more recent establishments in Cornwall occupies its own dwelling. They confidently hope that an appeal will be made which shall provide this society either with a separate building, or obtain the concurrence of the other public establishments of the town and neighbourhood in the erection of an edifice which shall afford the accommodation which all of them so greatly need.

At the last annual meeting it was fully contemplated that the fifth volume of the society's transactions would have been completed in the course of the year; but the pressing professional occupations of the Curator have, for the greater part of the time, removed him from Cornwall; it may, however, be confidently anticipated that it will be finished early in the ensuing season.

By order,

W. J. Henwood,
Samuel Pidwell, } *Secretaries.*

September 24th, 1841.

DONATIONS TO THE MUSEUM.

1. Sulphuret of tin, from the Carn Brea Mines; veins of tin ore in elvan, from Parbola Mine, and native gold, from Carnon Stream. By John Garby, Esq., associate of the society.
2. Stilbite, mesotype, jasper, analcime, thompsonite, chabasie, heulandite, apophyllite, laumonite, sulphate of barytes, zeolite, phosphate of iron, magnetic iron ore, oxide of manganese, lignite, amethystine quartz, agate, and other specimens, from Nova Scotia and New Brunswick. By Abraham Gesner, Esq., F.G.S., Government Geologist of N.S. and N.B., corresponding member of the society.
3. Native gold, and Jackotinga, from Brazil. By Percival N. Johnson, Esq., F.G.S.
4. A specimen of buck-stone, from Saugur Ghui Hill Fort, Bombay. By J. M. Davies, Esq., Hon. E.I.C.S.
5. Specimens of greenstone, with iron and copper pyrites, from New South Shetland. By Benjamin Bullocke, Esq,
6. Sulphuret of tin, from Carn Brea Mines; pseudomorphus oxide of tin, from Wheal Coates; and a fine specimen of copper pyrites in rectangular crystals. By Mr. Joseph Joseph, of Redruth.
7. Organic remains, from the limestone of Kerry. By Captain Stephen Thomas, of the Ardtully Mines.
8. Malachite, from Allihies Mine; and asbestus, from Blackball-head, County of Cork. By Capt. J. B. Reed, of Allihies.
9. Organic remains, from the slate rocks of Black-head, Mellendreth, Looe, Bodmin, and Polruan. By Charles W. Peach, Esq., corresponding member of the society.
10. Granite and greenstone, from Jersey; and granite, from Chauze, near Granville. By Richard Edmonds, Esq.
11. Specimens, illustrative of the conglomerates and raised beaches of the Lizard district. By the Rev. Edward Budge, vicar of Manaccan, member of the society.
12. A specimen of the fossiliferous rock of the Falkland Islands. By Commodore Sullivan, K.B.

13. Casts of the foot-marks of the Cheirotherium, and Sopwith's geological models. By Sir Charles Lemon, Bart., F.R.S., &c., president of the society.
14. A series of organic remains, from the silurian rocks of Lockport, State of New York, and from Dalhousie, County of Restigouch, New Brunswick; a series of specimens, from the rock formations of the States of New York, New Jersey, New Hampshire, Massachussets, and Maine, from Upper and Lower Canada, New Brunswick, Nova Scotia, and Prince Edward's Island; with specimens from the limestones of Meath and Kerry, and from the metalliferous veins in Meath, Cork, Kerry, and the Islands of Sark and Herm. By W. J. Henwood, C.E., F.R.S., F.G.S., Secretary of the Society, and Curator of the Museum.
15. A large specimen of quartz. By J. N. R. Millett, Esq., member of the society.

DONATIONS TO THE LIBRARY.

1. Contributions towards a History of Swansea: by L. W. Dillwyn, Esq., F.R.S. By John Henry Vivian, Esq., M.P., F.R.S., honorary member of the society.
2. On Irish Tin Ore: by Thomas Weaver, Esq., F.R.S., F.G.S., &c., &c. By the author.
3. A Mineralogical Report on a portion of the districts of Mellore, Cuddapale, and Cuntoor: by Lieut. Ouchterlony, F.G.S., Madras Engineers. By the author.
4. Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset: by John Phillips, Esq., F.R.S., F.G.S., &c. By Sir Charles Lemon, Bart., F.R.S., F.G.S., president of the society.
5. Proceedings of the Royal Society (1840–41). By the society.
6. Mining Journal from October, 1840, to September, 1841. By Henry English, Esq., F.G.S., member of the society, the editor.
7. Transactions of the Geological Society, vol. vi., part i., and Proceedings 1840–1. By the society.

8. Reports and Proceedings of the British Association for the Advancement of Science, for 1839–40. By the association.
9. Transactions and Proceedings of the American Philosophical Society. By the society.
10. Report of the Royal Cornwall Polytechnic Society, for 1840. By the society.
11. The ninth Annual Report of the Royal Horticultural Society of Cornwall. By the society.
12. Rules and Regulations of the College for Civil Engineers. By the Council of the College.
13. On the stratified deposits which occupy the northern and central regions of Russia: by R. I. Murchison, F.R.S., and E de Verneuil, mem. Geol. Soc., France. By R. I. Murchison, Esq., F.R.S., P.G.S., honorary member of the society.
14. Geology of the State of New York, 2 vols., 1839–40; 52nd Report of the Regents of the University of New York; Memorial of the American steam-boat proprietors relative to a legislative enactment. By W. C. Redfield, Esq., corresponding member of the society.
15. Letter to the Secretary of the United States' Treasury on steam-boat accidents: by W. C. Redfield, Esq. By the author.
16. Remarks on the Geology and Mineralogy of Nova Scotia, by Abraham Gesner, Esq., F.G.S., Provincial Geologist, corresponding member of the society. By the author.
17. First and second Reports on the Geology of New Brunswick. By Abraham Gesner, Esq., F.G.S. By the author.
18. "The Silurian System," an article from the Edinburgh Review. By W. H. Fitton, Esq., F.R.S., F.G.S., &c., honorary member of the society.

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TRANSACTIONS.

On the Conglomerates and Raised Beaches of the Lizard District.

By THE REV. EDWARD BUDGE,

MEMBER OF THE SOCIETY.

THERE are two subjects of much Geological importance in the neighbourhood in which I reside, which have not, I think, been examined so fully and attentively as they deserve. The first is the Conglomerate formation, which occurs so largely in the eastern angle of the Lizard district, to which Mr. De la Beche has just glanced in his Geological Report, but without entering into any of those details which are so necessary and interesting to the student; and without which no accurate opinion can be formed. The second subject to which I allude, is that of the Raised Beaches, of which we have some fine examples in the adjoining coast. Having had frequent opportunities of examining these formations, I venture to lay before the society the result of my observations, which, if they should be the means of thus calling the attention of any who have witnessed similar formations in other places, and of inviting the researches of more skilful observers, will not have been entirely useless.

In taking a starting-point to observe the conglomerate referred to, it should be first viewed on the northern side, a little way below the Nare Point. The floor of the beach is in one or two places composed entirely of it, and large masses of it are lying about in all directions. It also forms a portion of all the cliff that is

visible as far west as Gemerra, about the distance, I suppose, of a quarter of a mile. Here it is seen rising above the cliff, taking a south-westerly direction, and occupying a position between beds of argillaceous slate on one side, upon which it rests, and a vein of quartz on the other, having a similar direction, and which may be traced from the Nare across the parishes of St. Anthony and Manaccan, in the direction of St. Martin's, and towards the quartz formation of Helston Downs. The coast being here low, the conglomerate does not rise in any place above the high-water line, and must therefore be viewed when the tide is out.

It takes at this place the form of a coarse but firmly-cemented aggregate, the fragments of which for the most part consist of rolled pebbles of various sizes, and of different colours, which give the rock a mottled, and at times a beautiful appearance. Hornblende, schist, quartz, red sandstone, and greywacke, both in its solid and slaty forms, constitute the material of this stratum, which is cemented apparently by a ferruginous sand.* Further towards the Nare Point, or the low and sharply terminating ridge of rocks which forms the eastern angle of this district, it is met by argillaceous schistus, of which that point itself is entirely composed. Its position seems to be above the slate, as it forms the steep bluff headland known as Pennare Point. In this more elevated spot, as in all such cases, the rock assumes a texture much more close, hard, and compact. Its grain is altogether finer, and it much more resembles some varieties of greywacke. Lower down on the southern side, and at the base of the cliffs—at a point termed Carnmere—the conglomerate again assumes its more striking characteristics. The whole substance of the rugged cliffs, when the tide retires, presents nearly the same striking appearance of rocks once reduced to fragments and re-consolidated.

There is here a fine section of the cliff exposed, and a purplish coloured slate† makes its appearance in a very contorted state, seeming as if it rested on the conglomerate; but I believe this appearance is deceptive, as in all the cases that I have seen on the opposite side of the promontory, the conglomerate is evidently

* See specimens Nos. 1 to 5. † No. 6.

uppermost; and the appearance at this spot may be explained, by supposing that it is merely an overlapping of the argillaceous schistus. From Carnmere the formation is continued in a modified state, and skirts the shores towards Porthalla for nearly half the distance between the two places. It then seems to be succeeded by a formation of dark grey argillaceous schistus, hard, and full of quartz veins, which do not seem to have a continuation further inland. Here we must retrace our steps, that we may follow the line of the conglomerate on the northern side of the Nare promontory. After some alternations near the line of its junction with the slate (which is evidently a continuation of the rock that occurs in Mawnan cliffs, on the opposite side of the bay), we see it again finely exposed on the face of a low cliff on the western corner of Flushing Cove. This cliff, being always easily accessible, except when high tides cover it, and being almost reduced by the attrition of the waves to a flat and tabular surface, offers an advantage for viewing it which some other localities do not. It is here composed of larger pebbles than ordinary, and has all the appearance of a loose beach turned into a solid pavement. From this point the line of this formation is almost continuous along the southern shore of the estuary. Throughout this extent, which is more than a mile, it puts on a variety of appearances, changing from a coarsely-grained or arenaceous mass* to one of finer composition, and at intervals its appearance is but little different from slaty or compact greywacke. One circumstance will however, I think, generally serve to distinguish it—the manner in which it splits, or its cleavage, which is more or less angular, instead of being laminated and regular, like the beds of the schistose series.

It should be observed that the headland known as the Little Dinas is composed entirely of argillaceous slate, which continues on the north bank of the estuary for a short distance from St. Anthony's church. Here the conglomerate commences again, and very instructive sections may be had of it on the low cliffs on either shore. From the village of Carne, which stands at the head of the estuary, it may also be traced on both of the acclivi-

* Nos. 7, 8, 9.

ties of the deep gorge or valley which separates the parish of Manaccan from that of St. Anthony. It is most distinctly visible however on the Manaccan side. There is a quarry of it opposite Tregonwell mill, and from thence, ascending the hill towards the village of Manaccan, there is a large section of it laid open by the road-side, where it exhibits the appearance of a loose mass of clay and marl, more or less indurated. On approaching the church-town we find the formation assuming somewhat of the aspect of a variety of trap.* Greywacke and quartz appear to be more sparingly diffused in it; and on the glebe, talcose schist, sometimes with a greenish tint, abounds. Its course appears to be north-westerly, but its boundary in this direction is not, I believe, clearly definable. I imagine, however, that it meets the commencement of the serpentine and hornblende district somewhere in the direction of St. Martin's bridge, which is in the road to Helston. If, however, we follow it from Tregonwell mill, which lies at the foot of the hill leading from Manaccan to St. Keverne, we find it winding its way along the southern sides of the valley. Near Trevurgy mill it becomes very conspicuous, large masses of it being visible on the sides of the slope. These are a true trappean conglomerate, consisting of lumps of a compound of horneblende and felspar loosely aggregated by earthy and ferruginous matter.† Throughout its course, as it removes farther from the sea-coast, it loses by degrees its arenaceous aspect, and becomes a rock of more simple structure. Its cementing matter is homogenous with the material of which it is mainly compounded. Its fragments are angular, and do not appear to have been rolled, but rather to have been re-united very shortly after the substances of which it is composed were crushed or broken up. It seems also evidently to have been derived from the great hornblende formation of the vicinity; and its course may be traced almost so continuously from that of the Nare, that we are constrained to pronounce it to be of the same date. Its difference of character and aspect may perhaps be accounted for, if we suppose that the materials of that at the Nare had

* No. 10. † Nos. 11, 12, 13.

been for some time in a loose state previously to their consolidation, and thus more powerfully subjected to the rolling action of waters than those could be which were broken up the latest, and the soonest re-united. Little doubt can, I think, be entertained that these conglomerates are part of a great system, and that they are, as Mr. De la Beche has supposed, the continuation of those at the Nare Head, near Veryan. That they were produced at a period subsequent to the formation of the argillaceous slate, quartz, and hornblende-slate, is apparent from these rocks entering so largely into their composition. From their extent we may also infer that they were the result of causes that operated simultaneously and powerfully over a wide tract of country.

Mr. De la Beche has suggested that these conglomerates might have been produced at or about the period when the serpentine rocks were protruded, or perhaps a little earlier, as there are no fragments of that formation discoverable among the imbedded portions of this aggregate at the Nare. He admits, however, that as the drift of pebbles might not be in this direction, such an opinion is not entirely conclusive. A fact that has lately come under my own observation would, I think, have modified his views on this subject; for I have obtained a specimen from the parish of Mullyan of a conglomerate which occurs there in loose masses, the basis of which is serpentine cemented by calcareous matter.* And in Bellurian Cove, which is less than a mile distant from the spot where this was obtained, there is visible at low water the extensive remains of a conglomerate of a different basis, but of which carbonate of lime is the cementing material.† Unless this formation then be of later date than the one already described, we shall be compelled to consider the serpentine as a previously formed rock. The discovery of this rock in the conglomerate of Mullyan, and the absence of it from those of other localities, only serve to show that each has been derived from the older formations in its immediate vicinity. At the Nare, and in Manaccan, we might expect to find serpentine absent from the conglomerate; for the hornblende-slate formation is here much

* No. 14*a*. † No. 14*b*.

nearer than the former rock, and as the drift of pebbles seems to have been rather from north to south than from west to east (judging from the way in which the boulders of sienite are disposed on Crousa Downs), no conclusion seems fairly deducible as to the comparative antiquity of the formations just referred to from the one not being found imbedded in the other. There are two curious facts, however, which seem to occupy so natural a place in connection with the origin of these conglomerates, that it will be necessary to refer to them here. The first is the accumulation of an immense bed of sand or gravel on the highest part of Crousa Downs, in the parish of St. Keverne. This spot is a remarkable one, as embracing one of the most extensive sea views in the Lizard district; and it is, perhaps, almost the only spot in this district where a view may be obtained at once of the Lizard lighthouses and that at St. Anthony, near Falmouth. In appearance it differs but little from the flat region of Goonhilly Downs, on which it borders. Its elevation above the sea is 360 feet, being within twenty feet of the highest land in the Meneage, which is Roskruge Beacon. On this comparatively lofty site we find an accumulation of beds of fine yellow gravel disposed in extended layers, and containing a quantity of rounded quartz pebbles. That the whole accumulation must have been brought here, and reduced to this state by the action of water, no reasonable doubt can be entertained. The only question which seems naturally to arise in visiting this spot is, how it has happened that such a mass should have been deposited in a place that is higher than the generality of the district? The other fact to which I would refer, as possessing an interest in connection with the mighty agencies of water, as developed in portions of the country traversed by conglomerate formations, is the singularly flat surface presented by a large portion of Goonhilly Downs, and the bed of clay which overlies the serpentine rocks.

If conjecture may be indulged on a region where there is so much that is mysterious, I would suggest that the sand beds of Crousa Downs may, perhaps, have owed their accumulation to the circumstance of there having been once some great chasm or crater existing in this locality—perhaps the orifice from whence the sienite

rocks of the surrounding plains and coast were erupted. It is a conceivable supposition that at the period when the ejection of these igneous rocks, as well as those of the trappean conglomerates, took place, such eruptions might be accompanied by immense torrents of mud and ashes. The latter would form the cementing portion of those rock aggregations in which hornblende predominates. The former, derived chiefly from the siliceous and aluminous strata, might have been thrown out on the surface of the Goonhilly district. If also we suppose that there was subsequently a rush of the ocean waters over this and all the surrounding localities, tearing up the surface of the rocks and transporting their detritus to particular localities, through the agency of currents, we can understand how, while the crater or hollow I have supposed was filled with the heaviest portions of the aqueous and turbid mass, a large portion of the lighter and more comminuted particles might be swept along, and at length settle down so as to form the wide and level plateau of the Goonhilly Downs. Whether many also of the deep coombs or valleys, which are so common in the Lizard district, might not have been scooped out at this period, is a conjecture that I deem by no means improbable. I think there is strong reason to believe that the estuary in this neighbourhood, which was, I have no doubt, at one time filled with the conglomerate already described, owed its origin to some such cause. On both sides the formation may be traced almost continuously, lining its sides to within a short distance of the mouth of Gillan harbour. A loosely aggregated rock, such as this is, which is even now continually crumbling beneath the action of the tides, would be easily swept away, or channelled out; and it is a remarkable fact that the windings of the valley seem to follow, almost with exact precision, the course of the conglomerate, until we reach the hornblende-slate formation. Whatever conclusion we form on this subject, whether we carry back our ideas to the days of the Mosaic deluge (and surely it is not easy to imagine a more adequate cause), or whether we ascend to a remoter period, it is evident that some vast disruption or debacle is necessary to account for the manner in which the sienitic boulders of Crousa Downs are tossed about in the wild disorder which they now exhibit on the hills and cliffs in the vicinity of Coverack, and from

that point upwards, as far as the Manacle Point. Upon the whole, then, I think it is impossible to take even the most cursory view of the conglomerate rocks, as they present themselves in the localities to which reference has been made, without being convinced that the period in which they acquired their present condition was one of great disturbance and devastation; and that we have in these a standing memorial of some of the most violent and tumultuous changes to which our globe has been formerly subjected.

The Raised Beaches.

Closely connected with the formation just described, at least in point of locality, if not in antiquity, are the Raised Beaches, of which this part of the Lizard district exhibits many striking examples. They have not hitherto, perhaps, obtained all the attention which they merit, although Mr. De la Beche, in his Report, has casually noticed some of them. One of the most remarkable of these may be seen at Coverack. It occurs on the northern side of the Cove, at a little distance below the mill, and consists chiefly of large rolled pebbles arranged in very regular lines. Above, there is a thick capping of fine ferruginous sand, some of which is hardening into a stony mass, like the blown sand near Bude, on the north coast. Over this there is a bed of reddish-coloured marl or rubble: the sand and marl extend to the height of about twelve feet above the ancient beach, which is nearly five feet above the present high-water mark.

This specimen of a raised beach is an object of great interest, situated as it is in a large open cove, of easy access, and exhibiting a continuous section, for more than a hundred yards, of this ancient formation. Its position also is singularly striking, as it occupies a place, nearly at the extremity of that line, where rocks of diallage and saussurite intermixed, exceedingly beautiful and curious, are spread over the shores, at the foot of a highly picturesque village.

Beyond Porthalla, another good specimen of a raised beach occurs on the line of coast leading to the Nare. This commences at Nelly's Cove, which is about a quarter of a mile from that village. Mr. De la Beche has given a drawing in his Report, which conveys

a good idea of it; but he has not mentioned that this beach is continued for some hundred yards beyond this point. It however has the disadvantage of being accessible only at low water, and portions of it are seen, in some places, resting on steep ledges of rock still overflowed by the tide—a circumstance that seems to argue that the beach once extended itself over these as a platform, and that a considerable line of the rocky shores have here been abraded and washed away. This beach is interrupted by the rugged projections of the coast, but appears again at a short distance from the Nare, a little below Carnmere.

The most continuous and extensive sections of a formation of this kind in all the Lizard district, are to be seen on the northern side of the Nare point; with little interruption it may be distinctly traced for several hundred yards. Its elevation is, on an average, about five feet from the high-water level. The capping is a red marl, somewhat resembling that at Coverack, but of a deeper colour,* and containing fragments which in many specimens are not unlike the red sandstone formation near Plymouth. At one place this stratum of fragmentary *débris* rises from eight to ten feet above the ancient beach; and it appears to have a continuation at a considerable distance from this shore. Another section of it may be discerned at the back of the Pen-nare farm-house, which stands about midway in going across the promontory. At Carnmere it passes distinctly into the form of slate. That this stratum, allied, as it would seem, to the red sandstone formation, must have existed prior to the conglomerate, is evident from the fact that it is contained in considerable quantity in that compound, and it seems in some instances to be blended with the greywacke, giving it a curiously striped or ribbon-like appearance.†

One circumstance particularly observable in all the raised beaches that I have noticed, is the perfectly horizontal character which they preserve throughout their course: they seem uniformly to keep a line of direction parallel with the existing beaches on the shores below them. From hence it may be inferred that the relative changes in their position with respect to the sea—whether

* No. 16. † No. 4.

they have been raised above their ancient level, or the sea has retired from them (which I consider the most probable)—was not produced by any convulsive movement; and also that the strata on which the beaches rest have not since been exposed to any violent action, or the beaches would not have retained their parallelism, but would have been displaced from their present position.

With respect to the fragmentary *débris* accumulated on the raised beaches, the mass which rests on those at the Nare, and at Coverack, judging from the perpendicular sections exposed, varies from six to twelve feet in thickness. Mr. De la Beche has given a figure to illustrate this, as seen at Nelly's Cove, a little to the north of Porthalla. He supposes it to have arisen from the giving way of the hill above; and adduces it as a proof that the kind of cliff which rose behind the ancient raised beach, was similar to that which now rises above the present. The same observation will apply to the others which have been noticed, with the exception, that as no cliffs rise behind them, the mass of angular fragments and clay with which they are capped must be considered, either as the ancient cliff in a state of decomposition, or as a portion of that diluvial detritus which has been spread over so large a portion of the earth's surface. The first conjecture seems to me the most probable; since a mere mass of diluvium would probably have consisted of the detritus of a great variety of rocks, whereas these fragments are mostly of one description.

Whatever conclusion we may arrive at respecting the origin of these monuments of our former shores, it may not be uninstructive to mark the extent of the changes which they have already sustained, and are likely yet to undergo, by the undermining action of the waters of the sea. The progress of time is silently marked as by an index, in the extent of waste and injury produced by their encroachments.

At the Nare, the waves have hollowed out a cavern of at least 100 feet in length, and from the sinuous nature of the shore at this place, we may now walk at once along the modern beach, and under the ancient one, which looks almost like a solid arch of masonry overhead, from one end to the other. I have observed a similar

instance of a cavern thus excavated under the old beach, not far from Nelly's Cove already noticed. But this at the Nare is a singularly beautiful one. The exudation of the red matter from the sides of the rocks imparts a highly coloured tint to the confervæ with which they are overspread, producing the effect of a brilliant tapestry of scarlet damask.

Another instance of the progress of the work of destruction has occurred within only a few months. Through the undermining action of the waves, a large mass of the superincumbent bed has fallen in, and nearly filled up one of the caves at the Nare; but the raised beach still stands like the arch of a bridge in front of the sunken cliff, as if to show the firmness of the cement by which the pebbles and sand of which it is composed are held together. Judging from the wreck which has already taken place, it is hardly to be doubted that a few hundred years will abundantly suffice to obliterate all traces of the portions of raised beaches that still exist, and to sweep away from our cliffs these interesting and curious relics of the sea's ancient boundary.

An Account of the Fossil Organic Remains found on the South-east Coast of Cornwall, and in other parts of that County.

By Charles William Peach, Esq.

CORRESPONDING MEMBER OF THE SOCIETY.

It is about five years since the Fossil Organic Remains of the south-eastern coast of Cornwall first attracted my attention, and I have from time to time sent short communications to the society on the subject; but as I am likely soon to be removed from my present station, I now send a sketch of all the fossil remains which I have hitherto observed in this county, and the localities in which they have occurred, accompanied by specimens. The nature of my occupation has been such as to prevent me from taking more than hasty glances at the different points whilst attending to my official duties. I have therefore scarcely more than skimmed the surface; but, from the little I have seen, I have no doubt that a rich harvest will attend the experienced geologist who has time and opportunity to study the rocks carefully. From the resemblance which I have observed in the quartz rocks near Helstone to those which in other parts of Cornwall have been found to contain fossil remains, I am of opinion that they are fossiliferous, and I regret that I cannot visit and examine them. I have found fossils similar to those of Cornwall in the slates on Meadsfoot sand, near Torquay, and in the cliffs between Paignton and Brixham, in Devon.

In the sketch which I propose to give, I shall commence with the most western point of the coast, and proceed eastward.

Cairn, Gerrans Bay (Parish of Veryan); Diamond Rock, near Caerhayes, Great Cairn, Great Peraver, near Goran Haven (Parish of Goran).

In these places the quartz rock containing organic remains runs in a tortuous course almost in an E.N.E. and W.S.W. direction:

it frequently shows itself by large upbreaks, and may be traced in its course by scattered blocks. At its outcrop in the face of the cliffs it is shaken and rent in all directions, often appearing to have been broken into small pieces and afterwards re-united, forming an interesting breccia, the whole traversed by beautiful veins of milk-white quartz. The fantastic forms into which it has been thrown in various directions, show that it has been acted on by some very powerful force: it is occasionally micaceous, and speckled with oxide of iron; and in its various colours, as well as its hardness, mineral contents, and organic remains, it is much the same in all these places. It frequently encloses beautiful transparent crystals of quartz, as well as large opaque ones, and at the Great Cairn it affords specimens of iron ore. The organic remains are rather rare, and have hitherto been found only in the lowest parts, at the foot of the cliffs. The original matter of the shells is destroyed, and the space they formerly occupied coloured red, and frequently filled with a dusty oxide of iron; but the markings are well-defined, and the shells they represent appear to have been deposited in layers, showing the stratification of the rock; and notwithstanding the rock must thus have been formed under great pressure, and the shells suffered great smashing, they are not so much injured as might have been expected. Some of them are parted by the cracking of the rock, and the space filled up by a white vein of quartz, the parts of the shell being *heaved*, illustrating the manner in which mineral veins have been thrown out of their course. The organic remains yet discovered are all bivalve shells, evidently belonging to the great *Terrebratulite* family: they are nearly alike in all the places, differing slightly in size, being smaller at the Cairn in Gerrans Bay than at Caerhayes or Great Peraver.

The Van, near the Black Head.

In the Van, organic remains are found in calcareous slate in immediate contact with a greenstone trap dyke, which has discoloured the slate and the organic remains at the junction. In addition to *Encrinites* and *Corals*, may be mentioned a *Cyathocrinus*, with *Spiriferæ* and other mutilated bivalve shells. *Encrinites*

are plentiful, especially in the rocks between low and high-water mark, which are very calcareous. Corals and the other fossils are rare: the light colour of the fossils forms an interesting contrast to the dark-coloured matrix.

Between this place and the Slate Quarry a very fine specimen of *Orthoceras* has been found.

Slate Quarry, near the Black Head.

Proceeding eastward, fossils are again met with in the Quarry near the Black Head, formerly worked for roofing slates; and a very interesting series they are, comprising beautiful and delicate *Corals;* the impression of a rope-like *Encrinite*, and many other singular *Crinoidal* remains, with *Turbinoliæ*, the latter rare; also very faint impressions of bivalve shells. The slates are cut through by the Trap dyke which passes from the Van through the Black Head. From hence to Rope Haven, *Crinoidiæ*, *Turbinoliæ*, and *Corals*, are sparingly met with.

Porthpean.

In the cliffs on the eastern part of the beach are *Encrinites*, in a light-coloured slate, so ill preserved as to render it difficult to make them out.

Charlestown.

A few minute and ill-defined *Encrinites* are to be seen in the rocks under the Battery.

Apple-tree Cliff.

From Charlestown to Apple-tree Cove a few remains of well-defined *Encrinites* are to be found, some of them large; and what renders them particularly interesting, they are almost in connexion with the copper lode which shows itself in the face of the cliff.

Spit-point, Parr.

At Spit-point, Parr, small but well-defined *Encrinites* are sparingly met with, in a friable dark-coloured slate, below high-water mark; and to the westward of this spot, at Gull-rock Cove, I found a very beautiful specimen of *Turbinolia*, now in the Museum of the society. Crossing the Harbour, *Encrinites* and very interesting and singular *Corals* are found in a soft light-coloured slate, but they are not well defined.

Polkerris.

On the beach, below the inn, *Encrinites* and *Turbinoliæ* occur in a lead-coloured slate, which continues to some distance westward. The same fossils also occur, in a singularly contorted and finely laminated slate, in which light and dark layers alternate. At the back of the pier, the slates enclose black lozenge-shaped masses, evidently of organic origin, but so much defaced that nothing satisfactory can be made out of them.

Gribbon to Pridmouth.

In tracing the cliffs under the Gribbon, *Crinoidal* stems and detached vertebræ are sparingly met with, and also faint traces of shells. At Pridmouth, near Menabilly, I found a fine specimen of *Platycrinus*, with the column, pelvis, arms, &c.; also, in nearly vertical strata of exceedingly friable dark slates, minute stems of black trumpet-shaped *Crinoidea*, which fall to pieces in removing: they are numerous, but confined to one narrow spot. A short distance from them, remains of shells, corals, &c., are plentiful, in a brownish coloured arenaceous slate, but so indistinct as to render it impossible to get any good ones. The strata here are much disturbed. Below high-water mark, the recent *Pholas dactylus* is very plentiful, which shows either the presence of lime in the rocks, or their extreme softness. I incline to latter opinion.

Fowey Harbour.

The hill at the entrance of the harbour contains organic remains.

Ready Money Cove.

Near the lime-kiln I found *Turbinoliæ*, casts of bivalve shells—probably *Spiriferæ*, and also stems of a peculiar *Encrinite*, with very thin joints, having a groove running down the whole length: the strata are so arenaceous and friable, that it is a difficult matter to obtain good specimens. The cliffs along the harbour from this spot are fossiliferous, containing joints of *Crinoidea* and *Orthoceratites*, with large *Turbinoliæ* occasionally, especially under the cottage near the castle: the slates there are light-coloured, and traversed by quartz veins of a dark colour, which, with the fossils, are in relief, from the soft slate being weathered away. Nearer the castle the fossils are more abundant, particularly *Encrinites*, which, in some places, give the rock a porphyritic appearance. Some of the *Encrinites* are very large, as are also the *Orthoceratites* found there. There is one description of large *Encrinite*, which is rarely met with, which has the divisions formed of four or five thin plates which close at each end, and when a longitudinal section is shown, appear of a lozenge-shape: each plate is delicately striated on both sides, radiating from the centre. This was found in a bluish slate, in which is a great deal of calcareous matter. Here are also portions, possibly of fishes, and a Coral, like *Favosites*.

Between the Castle and White-house Ferry.

The fossiliferous beds here are contorted and bent in a singular manner: at one spot they form a series of vertical-sided arches; a little farther on, this is reversed: beyond this they are inclined at an angle of about 45° resting against strata perfectly vertical, the whole mixed with arenaceous beds, sometimes cemented by a black oxide of iron: occasionally a bluish hard rock is met with, highly calcareous, effervescing freely with acids, from the abundance of the organic remains. Near the ferry, in vertical strata, are great

quantities of shells, *Spiriferæ*, &c., of a red colour, in a light-coloured friable sandstone; small *Encrinites*, and several sorts of *Favosites*, are also in great abundance. The arenaceous slates here are exceedingly fossiliferous, abounding in joints of *Crinoidea;* but owing to the hardness of this rock, from the oxide of iron, and its breaking in every direction, it is not possible to obtain good specimens.

Quarry near the Rope-walk.

The fossiliferous beds are in thin seams in the upper part of this quarry. The fossils are rather abundant; but owing to the softness of a great deal of the rock, good and perfect specimens are rare. In addition to beautiful and delicate *Corals*, by no means plentiful, may be mentioned an *Encrinus*, also rare, which resembles the *Stag's-horn Encrinus* of Miller, figured in Parkinson's Organic Remains, vol. ii. pl. 13, fig. 75 and 76; beautiful *Turbinoliæ*, of different sizes; an elegant *Orthoceras*, the siphuncle large. This fossil appears to be like the *Actinoceras* figured in Lyell's Elements of Geology, p. 463, as found in Lake Michigan, in North America, and at Castle Espie, in the county of Down, in Ireland; also the impression of a *spiral shell (Terebra?)*; a singular specimen, very much like *Cololite.*

The rock on the side of the Rope-walk is also fossiliferous.

Polruan, St. Saviour's Quarry.

Here the fossils are not numerous: the most abundant are *Encrinites.* Very large and interesting *Favosites*, as well as smaller ones, and splendid and large *Turbinoliæ*, are also sparingly found. The fossils are in thin seams in a decomposed stone.

Quarry, near the Castle, back of the Coast-Guard Station.

Turbinoliæ and *Encrinites* are found here.

Punch's Cross Quarry.

Here fossils are abundant, especially *Encrinites;* very large and beautiful *Favosites*, some a foot in length, as well as small ones; *Spiriferæ*, *Productæ*, *Terebratulæ*, and several other shells; *Orthoceratites*, an *Amplexus* (?), portions of fishes, pieces of bone, specimens having very much of a plant-like appearance, portions of *Trilobites*, and remains also of a fossil the structure of which resembles *Sepiadæ*.

These rocks have been quarried for economical purposes, the beacon of the Gribbon being built with the stone from this quarry. Although fossils are met with in almost every part of it, they are most abundant in the upper part of each bed, so much so as to render it unfit for use. They gradually diminish towards the lower parts of the beds, so that in some parts the trace is nearly lost. This is the case in the whole of the beds which have a gentle inclination, and are not contorted.

Cliffs near the Flag-staff, and Eastward.

The fossiliferous beds appear again round the point east of the harbour. In the upper part are *Crinoideæ* in great plenty, mingled with lozenge-shaped masses, which may possibly be the heads of these interesting fossils; also *Turbinoliæ*, *Favosites*, with portions of shells, *Trilobites*, and probably *Sepiadæ*. In some parts the strata are highly inclined and very much contorted, and generally of a dark slate-colour. Eastward of the flag-staff they are of a brownish colour, highly inclined, beautifully curved, and fall from the cliffs in interesting masses, showing to advantage the relics which they contain.

Barcelona Quarry, between Pelynt and West Looe.

In the quarry on the right of the road near Barcelona ill-defined *Encrinites* occur in a brownish-red rock, in which is a great quantity of quartz.

Quarries at the head of the New Road near Port Looe, and the Rocks on each side leading to West Looe.

Near Port Looe, in a stratified, grey-speckled, hard rock, an equivalved bivalve shell, very much resembling a *Nucula*, with *Terebratulæ* and *Encrinital* remains, are found. *Encrinites* also occur in a quarry near the residence of Captain Walcott, R.N. The quarries at the head of the new road consist of a hard quartzose red or pink rock, traversed by small quartz veins. Here beautiful bivalve shells, evidently *Terebratulæ*, occur, with abundance of *Encrinites*, *Cyathocrini*, and other shells; the *Cyathocrini* are large and beautifully marked, the space they formerly occupied being filled with a bright-red ochreous earth. The impressions of the bivalve shells are peculiarly interesting, from their strong markings, the sharpness of the angles, and the whole being covered with dark minute crystals of quartz, giving them a serrated appearance. The greater part of the strata which have been exposed by the cuttings on the new road are composed of a friable arenaceous rock, which contains fossils agreeing with those found in the cliffs at East Looe.

Cliffs from West Looe to Port Netley.

The cliffs on the west side of the Looe are fossiliferous; but on proceeding west they become much less so, very few indistinct *Encrinites* being found from thence to Port Netley. Rolled stones, containing specimens similar to those from Port Looe, are by no means uncommon. The rocks for the greater part of the way have been cut down, almost to the level of the beach, in order to make a large slip; the parts that remain are in great confusion, and much contorted.

New Road, Common Wood, and Bank along the River, West Looe.

In the rocks exposed in Common Wood by the cutting of the new road from East Looe to Torpoint, interesting *Encrinites* and *Cyathocrini* are found, agreeing in every respect with those found

in the quarries near Port Looe, and embedded in a similar matrix; the bivalve shells are rather more plentiful, and differ a little, being coloured brown. In these cuttings a great many beds of limestone are exhibited, in which are innumerable indistinct portions of (probably) *Encrinites*.

Road by the side of the River leading to Morval.

On the side of the road leading to Morval, on the banks of the East river, the rocks are fossiliferous; veins of limestone are intermingled with the slates. At Steps, in a quarry about a mile and a half north of East Looe, *Encrinites* are found in a friable arenaceous stone, in thin seams, between the beds quarried for economical purposes.

East Looe, Guns Hill.

In the hill, called Guns, on which East Looe stands, I have found the most interesting and splendid Cornish fossils I have ever met with. Here is a rich mine indeed, which will afford a treat to those who delight in fossil geology. The matrix is a light-coloured quartzose rock, occasionally stained red, and spangled with minute crystals of quartz. At the foot of the cliff are immense quantities of *Encrinites*, as well as impressions of large shells, with *Turbinoliæ*, *Favosites*, *Fenestellæ*, &c. &c. A short distance from this spot, on the same level, is an inclined, soft, brownish rock, full of fossils similar to those last mentioned. Ascending the hill, the rock becomes more friable and arenaceous, and of a brownish-red colour; here it is extremely rich in fossils, *Spiriferæ*, *Productæ*, *Fenestellæ*, *Favosites*, &c. &c. On this spot I found one of the finest specimens of *Encrinite* I ever saw, a part of the column of which is tubercled. It has four auxiliary side arms—three on one side, one on the other; the *pelvis* peculiarly marked, something like the shield of a coat of arms, quartered and spotted; several of the *tentacula*, with the *pinnæ*, beautifully developed; and the extreme end of one of the *tentacula* has its head turned something like the recent *Pentacrinus caput Medusæ* noticed in Buckland's

Bridgewater Treatise. In the upper part of the hill fossils continue plentiful, in a soft arenaceous stone, intermingled with the slates, in which are exceedingly minute delicate corals and shells. Near the sea wall, against the parade, is a hard red rock, traversed by quartz veins, *Encrinites*, *Corals*, *Terebratulites*, &c. &c. abound.

From Guns to the Chough Rock.

Taking an easterly course, before reaching the Chough Rock *Crinoidal* remains are abundant in the cliffs—some of them white, in a dark matrix; in some of the blocks they are reddish, in a brownish-grey slate.

Chough Rock to Pleida.

In the Chough Rock, and from thence to Pleida, similar fossils are found. At Pleida the *Encrinites* and *Turbinoliæ* stand in relief from the matrix, which, being softer than the fossils, is weathered away. Here stems of a *Cyathocrinus*, in a dark grey wavy slate, with several consecutive vertebræ, and also very interesting specimens of (probably) *Cyathocrinus nodulosus* are found. On the west side of Pleida is a red rock containing abundance of *Encrinites*, with a few *Cyathocrini*, similar to those in the rocks of Common Wood, which are evidently a continuation of the same beds.

Mellendreth.

On the west side of Mellendreth, under the lime-kiln, *Encrinites* are plentiful; *Turbinoliæ* rare. After passing this point of rock, fossils become abundant in an arenaceous friable schist, *Encrinites*, *Turbinoliæ*, *Orthoceratites*, *Favosites*, *Productæ*, and *Spiriferæ*, with a great variety of other shells; in fact the whole of the rocks appear to be completely full of organic matter. The cliffs from this spot to a little beyond Seaton river contain very few fossils; the strata are very much contorted—a great portion in ruin and

confusion, from a large landslip. In the rocks between East Looe and Mellendreth, patches of limestone occur in the cliffs, containing immense quantities of *Encrinites* and other organic remains; from its hardness, and being susceptible of a polish, I have named this stone *Cornish Entrochal Marble.* The limestone appears in the whole of the slate in the vicinity of East Looe; there are also large blocks of crystallized carbonate of lime, red, white, and grey, scattered on the beach, and in the cliffs, as well as in the rocks on the river side: these blocks are solid, and would take a most excellent polish, and might be cut into slabs for tables, or used for other ornamental purposes.

Bodmin.

In the quarry on the hill behind the Assize-hall, *Encrinites,* both round and elliptical, occur; small ones are abundant: they are in a grey wavy stone.

Menheniott, Tregrill Slate Quarry, Rose Vale.

In this noble slate quarry a quantity of limestone is found, of a dark slate-like appearance; a kiln has been erected, and an attempt has been made to convert it into lime, but without success: it effervesces freely with acid. In this limestone small *Encrinites, Turbinoliæ,* with *Trilobites,* are imbedded: these fossils, however, are rare.

St. Austell Stream Work, Pentuan.

Here I have not observed any fossil remains, and as to the alluvium of Pentuan Valley, its contents have already been described in the Transactions of the society, by J. W. Colenso, Esq., I would therefore merely remark, that abundance of shells may be found in the refuse which has been thrown out in digging there; they agree in every respect with those at present found on this coast; the most abundant being of the description usually met with in estuaries.

Port Mellin, near Mevagissey.

At Port Mellin, after a heavy gale of wind which had scoured the beach very much, I observed the roots and parts of the stems of trees of considerable size, *in situ;* showing that this valley was probably once occupied by a forest. They were on clay, surrounded by alluvial matter, composed of flags, &c., in which were enclosed the *Elytra of Beetles*, retaining their primitive brightness. These do not belong to the general objects of this paper; still I thought them sufficiently interesting to deserve a passing notice.

In conclusion, I would apologise to the society for having been obliged to name and to describe the different fossil remains in the most general way; for little indeed has been the time which I have been able to devote to the study of fossil geology.

On the Pseudomorphous Minerals found in Cornwall, illustrative of a replacement of one mineral substance by another.

By JOSEPH CARNE, Esq., F.R.S., &c.

TREASURER OF THE SOCIETY.

It is well known that every mineral body is subject to certain laws of crystallization, and when the primary or essential form of the crystal of any mineral substance is discovered, it is not difficult for an experienced crystallographer to ascertain all the other forms or modifications which the mineral can possibly take; all of which are connected, either immediately or remotely, with the primary crystal. When, therefore, the mineral is found crystallized in either of those forms, it is supposed to be in its natural state—crystallized according to its own law. But it occasionally happens that mineral substances are found apparently crystallized in forms which naturally, and by their own law, they cannot possibly take; and even when the crystals have the natural form, their fracture and cleavage prove that they are not the natural crystals of the substance. Such crystals are known by the term "Pseudomorphous"—false form or figure. It is, therefore, a very interesting enquiry, how they have become so crystallized, or, if not really crystallized, how they have become possessed of forms which are not natural to them, but belong to other bodies? The only general conclusion to which we can come is, that the minerals which now appear are not the same as those which the crystals first exhibited—that either a partial or a total change has taken place, by which they have become either different varieties of the same substance, or different minerals altogether.

Some apparent transformations of minerals, especially metallic minerals, are not at all uncommon, and are easily accounted for. A mineral substance—suppose sulphuret of iron—is decomposed,

and the sulphur is disengaged from the metal, and, uniting with the oxygen of the water, or the air, or both, becomes sulphuric acid, which, again uniting with the metal, under the influence, probably, of certain changes of temperature, sulphate of iron, or vitriol, is formed. Thus the sulphurets of metals may become sulphates. Copper in its metallic state, when exposed to the action of other bodies, combines in various ways with their elements. This was strikingly evinced in the copper coins found some years ago near the Hayle Causeway, on many of which the oxide, the carbonate, and the muriate of copper were very visible.

These changes, however, are not replacements; neither are the new crystals pseudomorphous. The new mineral has not the same form as the old one, but has taken its own form. They are not what it is principally intended to describe in this communication, and are alluded to here merely for the purpose of exhibiting the illustrative specimen on the table, in which the change actually occurred in my own cabinet. Some time ago I found a specimen of iron pyrites rapidly decomposing. I took it out of the drawer and placed it in the window. Perhaps three months might have elapsed before I noticed it again: in the mean time the rain had entered through the crevices of the window, and had run over the specimen, and when I next observed it, I found it covered with crystals of sulphate of iron, and the decomposition had entirely stopped.

Another change to which I shall here allude, on account also of the specimens which illustrate it (and which is indeed a replacement, although not of one mineral substance by another), is that which takes place in the petrifaction of organic bodies, especially vegetable and animal substances. Here the stony or other matter appears to be gradually deposited as the organic substance decays, until it acquires the precise form of the decayed substance. The petrified wood found in many parts of England, and also the petrified bones and other parts of animals, are so common, that their discovery occasions no surprise; but when the matter deposited is a metal, the singularity of the case gives it greater interest, although there is, in reality, no greater difficulty in supposing a deposition from a metallic than from an earthy solution. Of this kind are

the pyrites mushrooms, and other animal forms, of Dorsetshire; and there are on the table some small plants in native copper, so exquisitely formed, that not only are the stems and the leaves quite perfect, but the very fibres of the leaves are equally so. Indeed a good botanist might almost venture to give us the names and description of the plants. They were found in a copper vein in Treskerby mine. How plants could possibly have grown or have existed in such a situation, we may, perhaps, be quite at a loss to guess, yet it is not easy to account for the formation of these specimens in any other way, for if we apply to them the term *lusus naturæ*, we may use it with respect to all organic remains. There is another shrub-like specimen of native copper from Condurrow on the table, which, however, does not bear so exact a resemblance to a plant as to be classed with the former specimens.

The next class of pseudomorphous minerals to which I shall allude, is that in which the change or replacement of metallic ores appears to be caused by the loss of one of the constituent parts—that part by which the metal is held in the state of ore—and the acquisition of another. Thus in the change which frequently takes place in iron pyrites from the sulphuret to the oxide of iron, the original body seems to have lost, or been deprived of, its sulphur, and to have taken up oxygen and water, the form of the crystal not being in the smallest degree altered. Of this there are several specimens on the table from Levant mine, which are now oxide of iron, but whose crystals are the natural crystals of sulphuret of iron; such as the octohedron, the dodecahedron, the cube, &c. Amongst these specimens there are two in which the change is not yet complete, but appears to be still in progress. In one, the whole is oxide of iron, except two small spots on the edge, which are still sulphuret. The other specimen is highly illustrative of the progress of the replacement. It is a part of a large cubical crystal which, it is evident, could not have been originally as it now appears to us; as a crystal cannot naturally comprise two substances, unless they are in chemical combination; but here we perceive the sulphuret of iron cracked all over, and the oxide appearing in the crevices, and on one side, the interior seems to have become entirely oxide. Mr. Haidinger supposes that the change

begins at the surface and gradually penetrates the interior; but in this crystal one would almost suppose that the change had commenced in its very heart, and extended from thence to its external parts. In these changes there is no appearance of decomposition, but the mineral, retaining its solid state, seems to have gradually and imperceptibly passed from one combination to another. Yet it is impossible to say that some degree of decomposition may not have taken place, although almost imperceptibly: even the brown tarnish which sometimes appears on the surface of crystals of pyrites may be incipient decomposition.

A replacement of the carbonate by the oxide of iron has also occurred. As the iron exists in the carbonate as a protoxide, the mineral has only to part with its carbonic acid to become an oxide of iron. This appears to have been the case in the six-sided tabular crystals in the specimens on the table from St. Just, in which the carbonate and the oxide may be seen in similar crystals on the same specimen.

The prismatic crystals of sulphuret of lead, called blue lead, from Huel Hope, in St. Agnes, probably belong to this class. They appear to have been originally phosphate of lead, which is easily decomposed by sulphuretted hydrogen, even at the common temperature of the atmosphere; and the same agent which decomposes the phosphate may, by parting with its sulphur, form the sulphuret in its place. Where the crystals are hollow, the external part only has been changed, and the internal afterwards dissolved; but where they are solid, the change is complete. In one of the specimens on the table several stages are apparent in the crystals: some are wholly sulphuret; others show the sulphuret with an external coat of phosphate; others appear to be partly sulphuret and partly phosphate throughout, and a fourth variety are wholly phosphate.

The converse of this change sometimes takes place by the sulphuret of lead becoming carbonate and phosphate. A specimen on the table shows the carbonate of lead in cubes, a form which is not natural to it.

The next mode of replacement to which I shall refer, and which is perhaps of the most frequent occurrence, appears to have been caused by the deposition of one mineral substance upon the crystals

of another, and the primary substance having been afterwards dissolved, the deposited mineral remains externally in the same form as that which has been destroyed. These crystals (for so we must call them, although improperly) are, therefore, usually hollow. Illustrations of this substitution will be found in hollow cubes of quartz from Huel Spearn, and also cubes of chalcedony from Craft-an-Verth, both in St. Just, the siliceous matter of which was probably deposited on cubic fluor. Rhomboids of quartz from St. Just, of which the silex might have been deposited on felspar, or more probably on pearlspar. Dog's-tooth quartz, and hexagonal pyramids of quartz, both from Botallack, in which the deposition was doubtless on calcareous spar. Flattened rhomboidal quartz from Botallack, which appears to have been deposited on carbonate of iron. Tabular quartz from Huel Edward, which even now incrusts the oxide of iron. Octohedral quartz from North Roskear, perhaps deposited on iron pyrites.

It will probably have been remarked, that in these specimens the deposited matter is invariably siliceous.

It is possible for hollow crystals to be formed by a different process. Mr. Haidinger mentions an experiment made by Professor Mitscherlich, of Berlin, in which solid crystals became hollow, and a crystallized substance was formed within them by the application of heat. He exposed crystals of hydrous protosulphate of iron immersed in alcohol, to a degree of temperature equal to the boiling-point of that liquid. Decomposition ensued, although the external shape of the crystal remained unchanged. On being taken out of the liquid and broken, each of them was found hollow, and presented a geode of bright crystals of the same substance. I have no idea that any of the crystals here alluded to were formed by this process; but there is a specimen on the table which highly illustrates it. The crystals are oxide of iron; they are all hollow, and filled with small crystals of quartz. Supposing the crystals to have been originally siliceous oxide of iron, the origin of the quartz crystals is evident.

The last class of minerals which I shall mention as illustrative of replacement, consists of those whose crystals are perfect of their kind —quite solid and compact—but not being in the natural form of the minerals which they represent, were originally, in all proba-

bility, crystals of other minerals. Such are the solid cubical crystals of quartz from Huel Alfred, and also from Botallack, which were perhaps originally fluor: on the Botallack specimen is a crystal in which the accuminated angles, often seen in fluor, are perfectly preserved. The nail-head crystals and also tabular crystals of quartz from Botallack, probably at one time carbonate of iron. Hexagonal tabular crystals of chalcedony from Balleswidden, in two specimens of which may be observed the different stages of the replacement; in one, the chalcedony is merely deposited on carbonate of lime, which is everywhere visible; in the other, where the carbonate of lime is seen at all, the line of it is but just perceptible, and in some parts it is wholly gone, and the solid crystal of chalcedony remains. Octohedral crystals of chlorite from Roskear: the primary crystal of chlorite is a flat six-sided prism, a form quite opposed to that of an octohedron: the latter, therefore, is probably a replacement of some other mineral, although it is not easy to say of what mineral.

The beautiful crystals of copper pyrites from Huel Tolgus probably belong to this class. They are in a form in which that mineral has rarely, if ever, before appeared—that of an obtuse rhomboid, one of the natural forms of carbonate of iron, some of which is still perceptible on the specimen; and of this it may be reasonably supposed to be a replacement. Another specimen* exhibits copper pyrites in solid cubes, which have probably replaced cubes of iron pyrites. Here also, I apprehend, we must place the crystals of oxide of tin from Huel Coates, in St. Agnes, having the exact forms of the various crystals of felspar That the tin has here taken the place of the felspar can scarcely be doubted, as the specimens on the table exhibit the change in almost all its stages. It is probable, however, that previous to the replacement by the tin, the felspar had become decomposed, and by giving out its alkali had remained in the state of a sandstone. Here is first the crystal of felspar, or rather sandstone, partially decomposed; another crystal shows that the tin has just begun to invade it; in another, it has made greater progress; two others are nearly equally divided—one lengthwise, the other crosswise—in which one half

* Presented by Mr. Joseph, of Redruth.

is oxide of tin, and the other half felspar; in another, only a little felspar remains at one end of the crystal; and others exhibit the complete replacement, and even a new crystallization, of tin on the first crystal. In a broken crystal, the fracture, lustre, &c., are just as they appear in the common rich tinstone of our mines.

In another mine in St. Agnes—Huel Primrose—crystals of oxide of tin have been found having the exact form of quartz crystals, in which the quartz may possibly have been invaded by the tin. I say invaded, for it is not a complete replacement, as a part of the siliceous matter still exists in chemical combination with the tin, forming a siliceous oxide of tin.

The crystals of Haytorite, from Haytor, in Devonshire, are also generally supposed to be pseudomorphous. Dr. Brewster thinks it likely that datolite was the original substance, which contains more than one-third of its mass of silica, and that the lime and boracic acid have been exchanged for an additional quantity of silica, and thus the whole has been transformed into chalcedony. In the same class have also been placed the octohedral crystals of hornstone found at Beeralston, on the evidence of their internal structure.

In attempting to account for these replacements, some have supposed that they have all taken place by the deposition of one substance on the crystals of another, and that after the dissolution of the original substance had left the hollow coat or mould of a crystal, this was subsequently filled by a second deposition. I can only say, that in all the fractured crystals which I have seen I have observed no marks of such distinct depositions. Others have supposed that after these moulds have been filled, the moulds themselves have been dissolved, leaving the form of the crystals perfect; but the peculiar state and circumstances of some of the specimens which have come before us would rather lead us to contemplate the possibility of a replacement of a solid substance by a solid substance, probably particle by particle, or molecule by molecule, with very little, if any, of what we usually denote by the term decomposition, and without any alteration of form or figure; but in what manner this is accomplished we must yet confess our ignorance. The only agent which presents itself to our minds is electricity, which daily accumulating experiments teach us has had much to

do with the formation, the decomposition, the reformation, the replacement, and the various combinations of mineral bodies.

Had the subject been treated more generally, it would have been easy to accumulate facts to a much greater extent, such as the replacement of the blue carbonate of copper by malachite, and *vice versa*, in Siberia, and at Chessy, and of the oxide by the carbonate of copper at Chessy, and in South America; with many other instances, but it is intended to confine this communication to the replacements which may be illustrated by specimens found in Cornwall and on its borders.

It will also have been observed, that these remarks have been confined to cases in which crystallized bodies have come under our notice, and these are, in fact, the only bodies which will admit of proof of the change which has taken place; but reasoning from analogy, it will scarcely admit of a doubt that the same process has been in operation, and is constantly proceeding, not merely in separate crystals, but in immense amorphous masses, both of earthy and metallic minerals, in different parts of the globe. The change, for instance, from copper pyrites to sulphuret of copper in the metalliferous veins, which Mr. Fox's experiments have shown to be easily effected, furnishes an instance, probably by no means solitary, of the possibility of such a replacement.

*Some Account of the Porcelain Earth found in the kingdom of Saxony and the principality of Passau, and of the circumstances under which it occurs: collected from German publications.**

By the late JOHN HAWKINS, Esq., F.R.S., &c.

In the two communications which have been made to this society on the subject of our china clay, I have stated with precision all the circumstances which I had opportunities of observing. These, taken collectively, have a strong tendency to reverse the prevalent notion of the origin of this friable rock, and of confirming the opinion which I ventured to express of its aboriginality. It is a question, however, of so much importance, that, should it ever be decided by the opinions of the majority of geologists in the way that I have pointed out, it must infallibly lead to some new views of the origin of many of our principal rock-formations.

That no means may be wanting to facilitate this decision, I have lately consulted all the information which has been published by the German geologists on the subject of a similar earth, which is employed as the basis of their principal manufactories of porcelain; the substance of which information I shall here communicate.

The first of these reports is drawn up by Mr. Oelschlagel, and printed in the year 1818, among the select papers of the Mineralogical Society of Dresden. It relates to the porcelain-earth, as it is called, of Aue, in Saxony, which has long been the principal material of the celebrated Dresden manufactory.

It occurs in a district of granite near Schneeberg, and in a spot where that rock assumes the form of a cone, the apex of which emerges through a mantle-like covering of micaceous slate. The porcelain-

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* This account was sent by Mr. Hawkins to the Society, in order that the circumstances in which porcelain-earth is found in Saxony, &c., might be compared with those in which it occurs in Cornwall.

earth lies beneath this slate in two beds, which are separated by a bed of granite. All the granite which composes the cone is in a very decomposed state, the felspar which it contains being *changed*, as it is supposed, into porcelain-earth.

The two beds of this earth vary in their thickness, as they extend horizontally from a few inches to three-fourths of a fathom, that of the intervening bed of granite averaging about one fathom; the greatest thickness of the three beds, which amounts to two fathoms, being observable near the top of the cone, where their position is most horizontal. The two beds do not wholly consist of porcelain-earth, but contain much quartz, hard felspar, mica, and pinite, all which are very irregularly distributed, the earth constituting only from a fourth to a fifth part of the solid contents of the mass. The purest unmixed earth was found in the upper bed, immediately in contact with the micaceous slate, which formed a covering of from three to four fathoms in thickness, and the fineness and friability of this earth was observed to diminish as it lay deeper, until it passed through all the degrees of induration, and terminated in a firm crystallization of felspar. Mr. O. has omitted to say whether the same gradation is observable in the lower bed of this earth; nor does he give us any other particulars of these two beds, except that the quartz and the mica occurred in such large masses as to be easily separated by the hand. With respect, however, to the intervening bed of granite, Mr. O. observes, that its composition fully corresponds with that of the main rock below, except that it contains here and there pieces of quartz, which occasionally attain a large size, and penetrate the two beds of porcelain-earth.

Next to Aue, the principal spot in Saxony where the porcelain-earth is obtained, is the village of Seilitz, near Meissen. Mr. O. was unable to ascertain the geognostical relation of this deposit to the fundamental rock. It is twenty feet in thickness, and is said to have a covering of clay which contains shells. The rock below it is a porphyry. This deposit consists throughout of porcelain-earth, mixed with grains of quartz, and particles of a greyish clay. Much variation is therefore observable in its quality, some portion of it containing masses of the pure earth of the size of a man's fist or upwards. The earth is easily separated by means of water.

This earth is more free from oxide of iron than that from Aue; but it shrinks more in the fire, and yields not so durable a porcelain. Mr. O. is of opinion that this deposit of earth has been formed by a decomposition of porphyry.

The next account of porcelain-earth refers to that which is dug in the principality of Passau, and which supplies the royal manufactories at Vienna and Munich. This report was drawn up by Mr. Gehlen, and was first printed in the Transactions of the Royal Academy of Munich, and afterwards reprinted in the second volume of Von Moll's Annals of Mining and Metallurgy.

According to Mr. Gehlen, the earth is found in a district of gneiss and granite, which rocks are, for the most part, near the surface, in a state of great decomposition, although subject in this respect to much variation; for instance, while the felspar in some situations occurs in every stage of disintegration, it is in others entire and unaltered, and in this last state it constitutes the rock which lies immediately over the fine porcelain-earth. The chief deposits of this earth are formed by stratified masses of decomposed felspar, alternating with a very decomposed gneiss, the beds of which underlie in an angle of 45° towards all the points of the compass, although to no great extent in any direction. These beds of porcelain-earth have a thin coating, above and below, of variously coloured earth, striped with a pure white substance containing small scales of half-decomposed mica. The writer observes that while the felspar on the one hand occurs in every possible stage of decomposition, the porcelain-earth on the other exhibits various degrees of fineness or of solution, some of it being so pure and impalpable as to be wholly suspended in running water, and other portions retaining a sort of grittiness to the touch, which seems to be occasioned by an imperfect or disturbed crystallization. The occurrence of the pure earth is very uncertain, which circumstance gives occasion to the greatest irregularity in the mining operations, which are here carried on in search of it; and to this, as well as to the decomposed state of a portion of the stratified rock, must be ascribed the frequent subsidences of the ground which have taken place, as well as the great expense of obtaining any quantity of the pure earth.

The particulars which Mr. Gehlen has published of the geognostical character and relations of the porcelain-earth of Passau appear to have given rise to a memoir of some length, on the origin of this earth, by another chemist, which has been printed in the Transactions of the same Academy.

The author of this memoir, Professor Fuchs, of Landshut, begins with the remark that the friable materials are in part originally formed as we find them, and in part originate in the decomposition of others. In many, he says, it is difficult to determine whether they have this or that origin, and this is the case with the porcelain-earth. Most mineralogists, indeed, believe that this question has been long settled, and they take for granted that the porcelain-earth has been formed by the decomposition of felspar; but there is so much to be said against this opinion, that we may justly wonder, he says, that it has ever been adopted by men of any eminence in science.

The principal arguments upon which he rests his opposition to this hypothesis, are the total absence of all traces of potash in the waters which flow from the decomposed mass of granite, and the occurrence of the purest porcelain-earth inclosed in felspar, and, *vice versa*, of felspar in porcelain-earth. He is nevertheless by no means disposed to adopt the opinion of this earth being an original product of nature; the prismatic form in which it is occasionally found, and the regular impressions which are often left by it in the firm rock, satisfactorily proving, as he thinks, an original form of crystallization. For these reasons, and because the researches of Klaproth had shown how many different substances had been hitherto confounded under the generic name of felspar, Mr. F. was led to the conjecture that the porcelain-earth of Passau might owe its origin to some peculiar mineral, which, like Labrador spar, and some other substances, had been mistaken for felspar. It was with a view to the decision of this question that he visited the pits where the best earth was dug, and directed his attention particularly to the felspar which was said by Gehlen to form by its decomposition the porcelain-earth. Here he found what he had suspected, that the mineral so named was essentially different, in its form and other characters, from felspar. The rock in which the

crystals of this mineral substance lie is a fine-grained or aggregated felspar, of a greyish colour. Few, however, of these crystals are entire; nearly all of them are, more or less, decomposed, having lost their lustre, their hardness, and their transparency, so that only the outward or crystallized form remains, and this friable mineral has all the properties of porcelain-earth. Acids, he says, have no effect on the hard crystals of this mineral, until they are reduced to powder, and digested in muriatic or nitrous acid, when a portion is dissolved. He then proceeds to relate the method which he employed for ascertaining the constituent parts of this mineral and their relative proportion. The result of his analysis afforded—of

Silica	49, 30
Alumine	27, 90
Lime	14, 42
Soda	5, 46
Water	0, 90

Mr. Fuchs thinks himself justified by this result, and the form of its crystallization, as well as its other characters, to consider this mineral as a new species, distinct from any known species of felspar, and to bestow on it the name of porcelain-spar, under which name I find it arranged in some of the most recent systems of mineralogy. He next proceeds to the analysis of the earth which he supposes to have been formed by the decomposition of the porcelain-spar. This earth, in its pure, compact, and natural state, produced—

Silica	46, 70
Alumine	31, 80
Lime	0, 46
Oxide of Iron	0, 82
Felspar*	3, 00
Water	17, 14

The same porcelain-earth, after a process of suspension and subsidence in water, yielded nearly the same results; nor was there

* The felspar accidentally mixed.

any material difference in that which was obtained by the analysis of the same earth in what he calls its crystallized form. Here it is proper to remark, that Mr. F. seems to regard the porcelain-earth of Aue, in Saxony, as precisely similar to this. The conclusion which he draws from this inquiry is, that the porcelain earth of Passau has originated in the decomposition of porcelain-spar, the mineral which he here discovered; for the proofs of which he refers to the gradual and obvious transition of the porcelain-spar into porcelain-earth; to the association of the two substances; and lastly, to the correspondence, which, by-the bye, is not very apparent, between the chemical constitution of the one and the other. As for the process of decomposition, says he, it may be satisfactorily explained; for in such a complicated mixture as this is, the presence of soda and the calcareous earth must have disposed the porcelain-spar to yield to the active agency of water and the carbonic acid, by which all the soda and the lime have been carried off in a state of solution, together with a portion of the silica. But here it is that Mr. F. feels sensible of the difficulties in which he is involved by the arguments which he had already made use of in opposition to this same hypothesis, and has recourse to a sort of reasoning which bears some resemblance to our special pleading. Where, says he, these other constituent parts of the porcelain-spar have been carried after their separation—whether they have penetrated the adjoining strata, and have produced there certain changes, or, dissolved in water, have emerged to the surface, and created mineral springs—cannot be ascertained. The last supposition, however, is the most probable; and even if we should not meet with such a spring in this district, it will make no difference in the conclusion; for it must have ceased to exist as soon as the process of decomposition was over, and this because, with the exception of the few crystals which are enclosed in the felspar, no undecomposed porcelain-spar is to be found anywhere. Not satisfied, however, with the conclusiveness of these arguments, he adds: "Admitting, as it may be said, that you have proved the origin of the porcelain-earth from the mineral which you call porcelain-spar, it by no means follows that all the porcelain-earth has been so formed; some of it may be an original production of nature, and some may

have been derived from felspar or some other mineral. To this he would reply, that as the porcelain-earth, as far as his knowledge extends, is found only in the strata of primitive mountains which have been produced by solution and precipitation, and as all are more or less of a crystalline structure, it is by no means probable that the earth should have been formed originally as it is now found; for a precipitation of this sort would be a very uncommon phenomenon in primitive mountains. Nor is it less improbable that it should be derived wholly from felspar; for this, on account of its large proportions of silica, has scarcely any tendency to decomposition, and the naked rocks of granite which lie on the surface of the earth, obstinately resist all the agencies which destroy most other minerals; and granting that something of this nature may be going on here and there in the interior of the earth, it cannot be supposed to extend far, and nowhere through entire strata or lodes, but occurs only partially, and the result is not porcelain-earth, but a steatitical clay.

"It is, nevertheless, not to be denied," says he, "that in rocks which contain felspar as one of their component parts, and especially in granite, gneiss, and porphyry, a mineral very much resembling porcelain-earth is often found, which has the appearance of having been formed by the decomposition of felspar, of the structure of which it exhibits some vestiges; yet, as undecomposed felspar is usually found near it, there is much reason to doubt whether the friable earth has been formed in this way." He escapes from this dilemma by expressing a belief "that besides Labrador stone, felsite and weïss stein, some other species of felspar may be found which readily decomposes, and thereby forms either real porcelain-earth (Kaolin) or a mineral very much like it."

It is in this very unsatisfactory way that Mr. Fuchs endeavours to account for the difference which he has ascertained, between the constituent parts of the porcelain-earth of Passau, and the mineral from which he has combatted his own arguments, and not very successfully; for after all that he has said in proof of the secondary origin of the porcelain-earth, in the latter part of his memoir, he has by no means weakened those arguments which were in the former part advanced against it.

I shall now return to Mr. Gehlen, who takes a different view of the subject, and reasons more consistently.

"It remains for me," says he, "to speak of the natural history of the porcelain-earth, and the use to which it is applied. I have already quoted the opinion which is universally adopted, of its originating in the decomposition of the felspar, and noticed its occurrence in a country of primitive formation, as well as the circumstance of its being found in its original position. This opinion of the origin of the earth is corroborated in fact by all the circumstances under which it occurs, both in the district above mentioned, and at Aue, in Saxony, where the beds of porcelain-earth lie in a rock of granite, which, by the decomposition of the felspar, is in a state of perfect disintegration. The various degrees too of decomposition through which the felspar passes, in which, with the loss of all its other characters, it retains those of its original structure, seem to confirm this hypothesis. On the other hand, if we contemplate the very great difference which is found between the chemical composition of the felspar and that of the earth, we must feel inclined to the belief that they can have no common origin, and that each is aboriginal. According to the recent analyses of the best chemists, the felspar contains a very great proportion of silica, as well as a considerable quantity of potash, while the porcelain-earth is found to contain not a trace of potash, and a much smaller proportion of silica. Rose found in the Saxon felspar 52, 0 of Silica, 47, 0 of alumine, and 0, 33 of iron oxide. According to a preliminary analysis, which I made some time ago, of the washed porcelain-earth of Passau, it consists of 55 of silica, 42, 5 of alumine, 1 of lime, and 1 of oxide of iron; while in the felspar from Kellberg, near Passau, I found 63, 0 of silica, and 20, 0 of alumine, besides potash, lime, and some iron. How then can so considerable a difference as this is, in the mixture of these two substances, have arisen from a process of decomposition? If we suppose this process to have set free the potash, which was afterwards carried off by the water, yet it is but reasonable to suppose that the proportions of the other constituent parts would have remained unaltered. This difficulty," he adds, "cannot be removed by the supposition that the potash may have carried off a

portion of the silica in a state of solution, and thus have increased the relative proportion of alumine; for there are many chemical facts which oppose this conjecture, and it must be abandoned as untenable."

Mr. Gehlen concludes without advancing any fixed opinion upon this very interesting question. Nor can I find among the voluminous writings of the German geologists any serious attempt made to settle it. The hypothesis of the secondary origin of porcelain-earth seems to have been generally adopted on the Continent.

The constituent parts of our common felspar having been ascertained by the most eminent chemists of Europe, I have added the results of the several analyses which they have made of it.

	The Green Felspar of Siberia. *Vauquelin*	Felspar of Lommitz. *Rose.*	Felspar of Bavaria. *Bucholz.*	Felspar of Carlsbad. *Klaproth.*	Porcelain-Earth of Saxony. *Rose.*
Silica	62, 83	66, 75	60, 25	64, 50	52, 00
Alumine	17, 02	17, 50	22, 00	19, 75	47, 00
Lime.....	03, 00	01, 25	00, 75	.....	.....
Aluminous Lime	.....	.....	00, 50	.....	.....
Oxide of Iron	01, 00	00, 75	.....	01, 75	00, 33
Potash	16, 00	12, 00	14, 00	11, 50	.....
Water	.....	.....	01, 00	00, 75	.....

NOTICES.

Notice of the Serpentine of Pennare.

Communicated by The Rev. CANON ROGERS, in a Letter to the Secretary.

Dear Sir,—Having been informed by my friend Mr. Trist that Mr. De la Beche and Mr. McLachlan had found serpentine near Pennare Point, in the parish of Veryan, I went with Mr. Trist to the spot, and send you, for the Cornwall Geological Society, some specimens, the result of our morning excursion, with a few short remarks on this interesting discovery.

After passing the quarry, mentioned by Dr. Boase, near Treganenna, and rightly stated by Mr. W. Tweedy to be of greenstone,* we found the serpentine cropping out on the eastern side of the headland which terminates in Pennare Point. It bears a much closer resemblance to the serpentine of Clickertor, near Liskeard, than to that of the Lizard district. It appears in small patches; and lower down the hill, and towards the beach, it is in such a state of decomposition as not to be easily recognized. The serpentine of Pennare has many of the same minerals associated with it as are found in the Lizard district. Greenstone of different degrees of induration, sienite, steatite, calcareous spar in thin layers, hornstone, or as it is sometimes, and perhaps more correctly, called, slaty felspar rock, and traces of asbestus and of fibrous calcareous spar. Some specimens bear much resemblance to jade, which has

* Transactions of the Cornwall Geological Society, vol. iv., p. 266.

been found in a rock near Caerhayes. The steatite may be observed in the cliff near the small bay, lying towards the east of Pennare Point. It is a constituent part of a decomposing rock containing imbedded fragments of serpentine. I searched in vain for the tremolite of Clickertor: and neither the asbestus nor the steatite are well defined. It is worthy of remark that the serpentine of Pennare appears in the mass to lie in a straight line with Porthalla on the south-west, the termination of the Lizard serpentine, and Duporth on the north-east, where the serpentine was probably quarried of which the porch of St. Blazey church was built. The serpentine of Clickertor lies to the south of this line. The potstone of Pollaphant would lead us to expect the presence of serpentine in that neighbourhood; and further and more accurate examination may perhaps add to those localities of serpentine in this county, which, with the exception of the Lizard district, have all been discovered within a few years. The serpentine of Pennare has, till very lately, escaped the notice of all geologists, and these brief remarks, the result of a very slight examination, may rather serve to induce persons who have both intelligence and leisure to examine the dip and relative position of this mineral, and the character of the associated rocks, than to give satisfaction to the geologist.

I am, dear Sir,

Your faithful Servant,

J. ROGERS.

Notice of an Ancient Smelting-place of Tin, generally called a Jews' House, lately discovered on the estate of Trereife, near Penzance.

Communicated by The Rev. C. V. Le GRICE to Joseph Carne, Esq.

Why these ancient smelting-places were called Jews' Houses it is not easy to conjecture, unless it was because the tin mines and tin trade, at the earliest period of their authentic history, were in the hands of the Jews, and it was therefore supposed that they were the principal parties concerned in still earlier times.

The remains of several of these places have been from time to time discovered in Cornwall, generally very near ancient stream-works, or the remains of the earliest mines, of which the works were all open to the sun. All that is usually seen is a narrow shallow pit, with a small quantity of charcoal ashes at the bottom, and frequently a piece of the smelted tin, which, although very pure in itself, is generally mixed with earth or sand, often vitrified. Tradition describes the earliest mode of smelting tin as of the simplest kind possible: a small excavation was made in the earth or sand, and small sticks were piled crosswise on each other, as high as they would easily stand, and, the crevices being filled with tin ore, the pile was set on fire, and the tin being smelted, ran to the bottom, where it became mixed with the loose earth or sand.

It is remarkable that Humboldt gives a similar traditionary account of the ancient mode practised by the Indians of South America in smelting their silver ores.

It is evident that only the purest and most fusible tin-ore could have been smelted in this way. Masses of tin supposed to have been so smelted are not uncommon. They are generally called Jews' Bowls. The largest I have heard of weighed thirty-four pounds;

it was found in a hedge in the parish of Gwinear, and having been offered for sale at the Angarrack Smelting House, the Goth of a refiner put it at once into a ladle and melted it down.

There is on the table one which was found in a stream-work in St. Just, weighing about six pounds. It is largely mixed with a sandy substance, and the outside is decomposing, as is frequently the case with the Jews' Bowls. The late Rev. Mr. Gregor analysed the decomposed part, and found it was muriate of tin: it is difficult to conjecture where the muriatic acid could have come from: Mr. Henwood has conjectured that dried sea-weed might have been used for fuel in the smelting. Even now this article forms a large portion of the fuel of the Scilly Islanders.

There is another on the table, which was found, only a few months ago, in Bossuliack Croft, near Lanyon, in Madron, in the centre of a barrow. The tin is of the purest kind, but mixed with vitrified matter. It is quite free from decomposition; but there is a crystalline substance connected with it, which is a combination of tin with chloric acid. This, under the old nomenclature, would be called muriate of tin. This piece of tin had doubtless been removed from the spot where it was smelted, as, about two feet below where it was found, there were flat stones covering a small cavity containing ashes, &c., evidently a place of sepulture.

In describing this earliest mode of smelting tin, I well know that I have related little that is not already known to most of those who have heard it, and it has been introduced only to show its connexion with the mode which appears to have been adopted at a later period; to which the spot which forms the principal subject of this communication seems to belong.

The smelting-place discovered at Trereife is (or I should rather say was) of quite a different character from those which have been already alluded to. As the workmen, during the absence of the proprietor of the estate, had removed the whole from the spot where they discovered it, the form, dimensions, and other particulars could only be known by very particular enquiry.

It was situated in the middle of a high bank of compact clay, which the workmen were removing, and when they dug into it, they found a space whose form was that of an inverted cone, about

three feet wide at the top, and three feet high. At the bottom was a flat stone, scarcely a foot in diameter, which had a border of small stones around its edge. On the flat stone were some unctuous ashes, doubtless of charcoal. The sides of this inverted cone, or furnace, for such it undoubtedly was, consisted only of hard clay. On one side of the bank of clay was a small ravine, by which it is probable a blast of air was conveyed, perhaps by a common bellows, to the lower part of the furnace, and by which also the smelted tin was discharged. The furnace, when discovered, was filled with earth and rubble, on the top of which was found the slab of tin now on the table, of the weight of twenty-six pounds.* It could not have been smelted where it was found, but was probably placed there with the intention of subsequently removing it, but which was never done. From an examination of the slab, it will appear evidently to have been cast in a mould, as the Roman letters E I C, with a figure of a cross surmounted by a kind of standard which very much resembles the Roman Labarum, are in relief on one side.

The situation of this smelting-place must have been very appropriate. On one side of it, within a few hundred yards, are the remains of the ancient tin-work of Trewidden, where the large excavations, still open, make it probable that an immense quantity of tin-ore was found there, not far below the surface. In another direction, not far from it, is Huel Garth, now called Huel Darby, where also, some time ago, were the remains of ancient mining, and which has recently been remarkable for the production of wood-tin in the upper part of the vein; but independently of these, there are remains of an extensive stream-work quite close to the smelting-place, which, however, will not long be visible, as the common is being improved.

With respect to the period when this mode of smelting tin was first resorted to, it may, perhaps, be not an improbable conjecture that the first or earliest method which has been alluded to was that of the Britons, and was continued by them until they were

* This has been presented, by the Rev. C. V. Le Grice, to the Natural History and Antiquarian Society of Penzance.

conquered by a people more highly civilized than themselves. The smelting-place at Trereife was, probably, an improvement introduced by the Romans, and seems to be a specimen of the very earliest kind of blast furnaces, or blowing-houses, the name long afterwards given to them. These furnaces were gradually enlarged and improved until they arrived at the form now in use, which, in fact, is little more than an inverted cone swelled out in the middle. Small blast furnaces were so easily erected that they were formerly very common in Cornwall, and have given the name to several localities, of which there is an instance in "Blowing-House Hill," near Redruth.

Tin was continued to be smelted in blast furnaces only, until within the last two hundred years, for reverberatory furnaces, such as are now used, are of comparatively recent date: the reason of this appears to have been the general persuasion, that to melt tin with pit-coal would greatly injure its quality. The first furnace of this kind was erected at Calenick, near Truro; the second at Angarrack, near Hayle.

The fact that this slab of tin was smelted in the time of the Romans, is rendered more probable in that it was a common custom with that people to affix letters, and even inscriptions, on the melted slabs of different metals. Pennant, in his "Wales," mentions several pigs of lead found in the Roman smelting-places, some with letters, and others with contracted words, all in raised capitals. He also mentions the discovery of a cake of copper, in shape like a cake of beeswax, with letters on it.

Additional contributions to the Mineralogy of the Parish of St. Just.

By JOSEPH CARNE, Esq., F.R.S., &c.

TREASURER OF THE SOCIETY.

The parish of St. Just is undoubtedly one of the most interesting districts, with respect both to its geology and mineralogy, and one of the most fertile and productive, with regard to the number and variety of its minerals, that exists in this or perhaps in any other country. Indeed so different is it from every other part of Cornwall, that occurrences which would be deemed singular and extraordinary elsewhere excite little astonishment here. The associations and combinations of its different minerals are such as are met with nowhere else.

A few years ago, a descriptive account of the minerals known to have been found in St. Just, astonishingly numerous and various, was laid before the society, and subsequently published in its Transactions.* Since that period many additional minerals, and additional varieties, have been found, which were not previously known to exist there. A short description of these will not be altogether useless, if it only conveys additional information to the mineralogists who may hereafter visit that district.

The minerals discovered since the publication before mentioned may be divided into two classes. The first class are either massive, or crystallized in their natural or regular forms; or they are in new associations. Here may be mentioned arragonite of a white and brownish-white colour, botryoidal, and in hexahedral prisms; and also of a deep red colour, both in concretions, and crystallized in hexahedral prisms, some of which are crowned with very obtuse

trihedral summits; and in others, which are double-pointed, the angles at one end of the crystal are parallel to the planes on the other: all from the Levant mine. Selenite, or crystallized sulphate of lime, in its usual form, the oblique parallelopiped, from Roscommon cliff. Isopyre, from Huel Carn, a mineral much resembling black opal, but being found by Mr. Heidinger to be a different substance, he has given it the name of isopyre. Quartz in the rhomboidal or primitive crystal, and also in long slender pyramids without any prism, both from Botallack. Striated carbonate of lime, much resembling sulphate of strontian, also from Botallack. Needlestone, from the same mine. Native silver, dentritic and in elongated octohedral crystals; and also capillary native silver on arragonite, from Levant. Grey sulphuret of copper in arragonite, also from Levant. Copper pyrites crystallized in hexahedral tables, from the same mine. Pitchblende from Huel Edward and Botallack: this mineral has been so named by Mr. Brooke, but it appears to be different from the mineral which usually bears that name, as it contains a considerable portion of copper. Phosphate of iron in acicular crystals, and in flattened prisms with wedge-like summits, and also in small globular masses, from Parknoweth. Earthy phosphate of iron, of a smalt colour, from the same spot. Oxide of iron in hexagonal tables, of which the centre of the crystal is a complete triangle, from Botallack. Carbonate of iron in globular masses, from Huel Cock, in some specimens of which the first formation is covered by another. The same mineral from Botallack, in greenish hexagonal tables. A singular ore has been found in Levant which Mr. Fox considers a binary sulphuret of copper and lead, a mineral which I believe had not been previously known.

Besides the minerals which I have mentioned, there are several others which I have received from this parish, which I find it difficult to name, and until they are analysed it will not be easy to classify them. One has some resemblance to oxide of zinc; three or four others are undoubtedly ores of copper, but their peculiar composition it is difficult to determine; and there are several of which I must confess my entire ignorance: one of them when it was brought to me from Botallack, perhaps twelve months ago, was

so soft as to be easily pierced by the nail, but it is now as hard as quartz.

The second class will comprise the pseudomorphous minerals; viz., Chalcedony in cubes, from Croft-an-Verth, and in hexagonal plates, from Huel Edward and Balleswhidden.—Quartz in cubes, seen with the angles accuminated (as they are frequently seen in fluor), and in dog's-tooth crystals, and other crystals naturally the form of carbonate of lime, particularly the compressed rhomboid known by the name of the nail-head, all from Botallack; and in tubular crystals from the same mine, and also from Huel Edward. Oxide of iron in octohedrons, dodecahedrons, cubes, hexagonal tables, and other more intricate forms, from both Levant and Botallack; and brown hematite, in cubes, from the latter mine.

The pseudomorphous minerals would have been more particularly described had they not been already noticed in another paper on that subject (page 24).

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THIRTIETH

ANNUAL REPORT

OF THE COUNCIL,

WITH

THE PRESIDENT'S ADDRESS,

AND

PAPERS AND NOTICES

READ TO THE SOCIETY.

PENZANCE:
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PRESIDENT'S ADDRESS.

IE second year of our new plan of publication has now closed, d I trust that, if persevered in, it will attract to our Society, not ly the attention and good-will of those who properly belong to , but that it may induce the Geologists of other parts of England regard our proceedings as the efforts of men labouring in the bordinate but useful and necessary departments of their science, promote a common object. They have always recognized the rnish Geological Society as the first offspring of the great Society London. Its establishment was only the second step in the rise Geology in England, and its productions have ever been regarded important contributions to science. I hope and believe that, der the new system which we have adopted, the interest which us at first bestowed on us, but became dormant and almost extinct ring the inactivity of our Society, may revive, and place us again the stream which is now carrying on the science of Geology at ch an amazing rate. I think there is already evidence of this urning interest.

The last address of the President of the great Geological Society, livered on the 17th of February in this year, contains an extract m our report, read in this room only in the autumn preceding; thus oving that words and opinions uttered here have been printed and culated from hence, and afterwards digested, criticised, and read ain in public in a time little exceeding four months. This ra- lity of circulation is a very important consideration, which I would ess on all those who desire to lay their ideas before the public in printed form, and with the least possible delay. They may calcu- te on the certainty that their productions will be in the hands of e great masters of our science before the busy scene arrives when en of science are collected in London, and when the contributions

of provincial Geology are constantly poured into that great reservoir of knowledge.

There are few of these great masters who are not numbered in the list of our honorary members, and they are now, and will continue to be, entitled to our publications as they issue from the press.

If, then, the germ of Geological science still exists amongst us, it will have a convenient opportunity for its development. If it does not exist; if there are not amongst us men inclined to devote a portion of their time to speculative enquiries; if art has superseded science; and if Geological science (our peculiar province) is to be forgotten in the midst of the honourable activity of other branches of human enquiry, why, of course, the opportunities to which I have alluded are of no value; our Society will remain as a monument of former energies and former times; and the best that men can say of it will be—*Olim floruisse audivimus.*

But I have no such presentiment. We have yet some active and valuable contributors; and I have no doubt that their numbers will be increased when the opportunities which this Society offers to those who think on Geological subjects, of bringing their thoughts before the public promptly and in an authentic form, shall be fully understood.

The attempt which has been made to draw the working miners to communicate directly with us has not been successful. The premiums offered especially to them have met with few claimants, and we have yet a sum of £15 in hand unappropriated. I think, therefore, that it is time to modify the plan of premiums, and to make some new experiment with a view of leading the practical men of the county to co-operate with us. It has occurred to me to suggest the following scheme, and I have no doubt that the two gentlemen who concurred with me in the first instance in the offer of premiums, will also concur in some such change of method, by which our object may be obtained.

I would propose, then, that the money in hand should constitute the foundation of a fund for premiums, and that other individuals should be invited to throw in their contributions from time to time as the fund becomes exhausted; but that the Society should annually, out of its surplus revenue, make an addition of £10 to that fund,

ıd that the Council should be empowered, according to their dis-
etion, to distribute the amount in the manner which they shall con-
ler most beneficial to the Society, and to the science which it
ltivates. This latitude will empower them, not only to recompense
ıst services, but to grant assistance to those who require it, to en-
ıle them to prosecute their labours for the benefit of the Society.
ıis plan has been very successfully in operation with the British
ssociation; and an instance of its effect may be seen in the sums
hich have, in two successive years, been voted to our industrious
ıuntryman Mr. Peach, and which have enabled him to make very
luable returns to the society which patronised him. We have
so great obligations to him; year after year he has added to our
llections, and still more to our knowledge, from the fruits of his
bours; and I have no doubt that we shall not only pay a just debt,
ıt lay out money with prospective advantage, if we should afford
ım a little aid to enable him to work more effectually in our service.
he British Association have twice voted him £10; I think we
ıould do well to add £5 from our premium fund, as a donation
om ourselves in return for what we have received from him, and
ı incitement to him to persevere in his contributions to us.

Amongst the instruments which the last year has afforded for
asoning on the Geology of our own county, I must put foremost
ıe very extraordinary discoveries which Mr. Peach has made of the
ımains of those characteristic fossil fish, the absence of which
emed to break the chain of evidence by which our Geological
ısition was to be determined. I know that this absence did not
ıake the faith of the authors of that system in the conclusion
hich they had adopted. They rather felt that the peculiar con-
ition of the Cornish killas made it unreasonable to suppose that
ıch evidence would be afforded in this county; and that the high
egree of mineralisation of our rocks almost precluded the possibility
organic forms being preserved in them. Sir H. De la Beche
ısists much on this effect of the changes which our altered rocks
ave undergone; and this view seems also to agree with the ex-
erience of Mr. Griffiths as to the slates of the Devonian system in
eland, which, he says, in the absence of fossils, can be determined
nly by position and mineral character.

It is satisfactory, however, to perceive that this link is now supplied. The specimens produced by Mr. Peach before the Geological section of the British Association, are universally admitted to belong to that class of extinct animals which characterise the oldest rocks, be they Devonian or Upper Silurian, in which the remains of vertebrated animals have been discovered; and the evidence of our Geological position is now complete. Mr. Peach will in the course of this meeting read a paper on the subject of his discoveries. He will give his own observations, and show how far the organic remains found by him do or do not correspond with those already described. I wish only to bespeak faith in the statements he is about to make, on account of the credit given to them by the Geologists and Naturalists assembled at Cork.

I believe we shall also hear read a paper by Mr. Edmonds, giving an account of the recent occurrence of a sudden wave, and rush of water on this coast; occasioned, there is every reason to believe, by a violent elevation of the bottom of the sea. This is a very important subject, and possibly may have an extensive bearing on the Geological phenomena which we see around us. We have been in the habit of considering such disturbances of the earth's repose as belonging, with few exceptions, to particular countries, and generally to the neighbourhood of volcanoes; observation, however, has proved that they are common elsewhere.

The committee appointed last year by the British Association to draw up a report on Earthquakes have enumerated no less than thirty distinct shocks in the course of the year, ending on the first of July last, at Comrie, in Perthshire, alone; and have recorded several cases in other parts of Scotland, and at Manchester: we have also in this county experienced several such movements; one of which was plainly felt at Falmouth, and I believe it extended even to this place. This occurred about a year and a half ago.

We have here, then, in this recent instance, an agent at work, having power to produce a sudden elevation of the earth's surface concealed indeed from our sight, but proved to have occurred by the wave then generated.

Whether or not the surface raised has returned to its former position, we have no means of determining; but it is natural to

suppose that the same power may, in some other instances, have left a permanent change in the level of the coast; elevations or depressions, as the movement upwards or downwards in the oscillations of the strata was in excess. Proofs of permanent elevations we have in abundance, derived from the numerous raised beaches described by Sir H. De la Beche, Mr. Carne, Mr. Fox, Dr. Boase, Mr. Budge, &c.; and from the writings of the former gentleman I gather it to have been his opinion, that the various submerged forests which are found in different parts of our coast, are more probably the effect of internal movements of the earth itself, than of any other cause. This is a very interesting subject, daily acquiring more importance. Mr. Budge has given us very valuable information as to the raised beaches in his neighbourhood; but he seems to have been conscious that he had not exhausted the subject, for he concludes his last paper with these words: "In connection with the raised beaches of "the coast, it is a remarkable proof that from some cause or other "there has been an alternation of sea and dry land over extensive "tracts in this district; but it may still be a question whether these "elevations and depressions of the sea-level have not been of a "local rather than of a general character."

Sir H. De la Beche also leaves it as a point to be determined, whether or not we should treat the several effects of elevation and depression, which he relates as evidence of a general movement operating on a great part of Western Europe, or as a multitude of local movements effected at different times. I think he inclines to the opinion that, within limited districts, the changes noticed have occurred about the same period; still he does not speak confidently as to the connection of any two individual cases.

There is here the thesis of a very interesting disquisition, which I hope Mr. Budge may be induced to follow out; and to prove to us, not merely the extent and situation of the raised beaches which he has remarked, but their mutual connection, the angle which they present to the sea, and perhaps also the direction of the force which has operated to raise them. Possibly he may arrive at some further evidence of the double movement described by Sir H. De la Beche, and insisted on by Mr. Austen as characterising a portion of the coast of Devon.

In the last part of the Geological Transactions, the latter gentleman writes thus: "Within a comparatively recent period, the sur-"face of this part of England was placed at nearly its existing level; "then it was much lower; and it has again been raised to its present "elevation; and these movements must have been recent, because "the shells found in the raised beaches indicate a temperature like "that of the present time."

The same records from which he drew his conclusions are inscribed on our coasts; we have also raised beaches, and a depressed forest; and, further, we have the evidence of stream-works, which he did not possess: and when these are brought fully to bear on the subject, we may find reason to confirm or modify Mr. Austen's assertion, "that the amount of oscillation has been unequal in "different parts of the coast, but the greatest vertical movement did "not much exceed 70 feet; that the whole of the West of England "has experienced similar movements, the amount of elevation in-"creasing from east to west. And we may perhaps infer that such "tracts as the ancient forest beneath Torbay, now permanently sub-"merged, are portions which have not regained their former level."

Sir H. De la Beche computed the maximum elevation in this county to have been 50 feet, and so did Dr. Boase.

A curious instance of such a double movement was brought before the Geological Society in a paper read at one of the early meetings of this season. It appears that there is on the coast of New Holland a submarine forest, the stumps of the trees of which, now converted into stone, have been raised again, so as to project, in some instances, as much as four feet above the sea. Being so completely mineralised, they are not in the same condition as the vegetable remains on our coast; but are rather in the state of those trees figured in a drawing from the Bolton railway, which I had the honour to present to this Society; and they rest on the same formation; namely, the carboniferous slates and sandstones, into which their roots penetrate. It appears, therefore, that after having attained their full growth, they must have been sunk deep in the earth, and remained so long in that position as to have undergone the change of their substance into stone: and as they were finally raised again to a level above that of the sea, we have evidence of their threefold existence, and of their having undergone, at least, two dislocations.

Before I quit the subject of raised land, let me briefly refer to a ry interesting lecture delivered this year by Mr. Lyell, in which brought to bear on this theory a species of proof very rarely to obtained in Geological reasoning—I mean Historical testimony. traced from narrated facts of classical times, and from old al instruments of less ancient date, and also from the evidence Architecture, the progress of a gradual change of level of a part the Mediterranean shore, which Geologists had noticed as a fact, t could not bring within the history of man. Mr. Lyell has on e contrary precisely fixed its date, and given a positive value to e comparative chronology of the Geologist.

As I have referred to Mr. Austen's paper, I beg to occupy you r a moment longer, that I may draw your attention to one or two ssages in which he states the result of his observations on the anites of Dartmoor. These, he says, bear evident marks of having en protruded at three separate epochs, and are of three distinct es. I am not aware that the same remark has been made with ference to the granites of Cornwall, which are a prolongation of e same range, and I believe have been considered as identical in bstance. A single remark of Dr. Forbes, in the second volume of r Transactions, p. 263, is one of the very few instances in which attempt has been made by any of our native Geologists to termine the relative ages of our granitic masses. He says, that observed granite veins penetrating and shifting other veins; us indicating a second injection of molten matter into crevices the first mass already consolidated.

I am well aware that it is easy to be misled by these appearances shifted veins, and Sir H. De la Beche has used much caution reasoning upon them; but Mr. Austen has adduced several stances where the granite itself has suffered from the violence d disruption which it has inflicted on the superior strata; and he nfirms his argument by a reference to the general appearance of e district. This he describes in the following words: "The general direction of the Axis is about S.W., and N.E.; and we should naturally find in the undulations of the surface of the erupted masses a general parallelism, in conformity with this direction. Such however is not the case; the whole surface

"showing north and south lines of hills, valleys, and watercourses; "a circumstance which suggests that the present outline and con- "figuration of Dartmoor are the result of disturbing causes which "have acted subsequently to its projection."

I know not how far the circumstances occurring in Cornwall may justify us in adopting the conclusion to which Mr. Austen has arrived. The map of Cornwall attests the fact that the general direction of the watershed is at right angles to the axis of the granite range. But I presume that Mr. Austen does not mean to impute the vast interruptions in the great chain of our granite, which has been cut across from north to south, to subsequent movements of the granite mass itself. They seem rather to indicate that when the great effort was made which threw up such lofty mountains of erupted matter, certain obstructions and oppositions of the strata in particular places occurred, which prevented the granite from reaching the surface in one continuous line.

It is worthy of remark that Dr. Boase seems to have observed as a fact that very parallelism in the subordinate features of a granite country which should, according to Mr. Austen, when undisturbed, range beside the principal axis. He says, that the granite of this county may be divided into three ranges parallel to each other, and running N.E. and S.W.; a direction common to the adjacent strata, and to the principal metalliferous veins. He does not infer that the smaller groups had a different origin from the larger ones; and even thinks that there are no good reasons to justify the opinion advanced by Mr. Conybeare, that the granite of Clegga Point had any newer than the common origin. He relates, however, instances where one sort of granite is imbedded in another, presenting appearances similar to those shown in one of Mr. Austen's wood-cuts. As to the parallelism itself, it in no way contradicts Mr. Austen's theory, but may be reconciled with it by the supposition, that the granite of the district to which Dr. Boase's remark applies, was not subject to that second movement which broke up the natural features of the granite country described by Mr. Austen.

In the early part of the present season a paper was read exhibiting some curious views with respect to the formation of granite, and showing that there exists, in the chemical composition of the rock

tself, evidence of its having been formed under different circumstances, and, as the author infers, at different times. He divides it, according to its chemical characters, into two classes. Ancient granite is characterised by an entire absence of magnesia, but abounds in hornblende: potash, soda, and lithia occur in it, but none of the alkaline earths, or metallic substances. Secondary granite, on the other hand, owes its character to the admixture of the components of sedimentary rocks. Thus the absence of mica in its due proportion, and the presence of magnesia, lime, or metallic matter, or the tendency to pass into sienite, are indications of the later rock; and all binary granite, being subordinate to primary granite, is of this class; and thus granites, according to their age, are divided into alkaline, and alkaline-earthy.

According to this theory, the granite of Cornwall and Devon belongs to the later date. But we can obtain no proof of this fact in Cornwall, because we have no means of comparing our granite with rocks less ancient than killas. Mr. Austen on the other hand shows, that the intrusion of the granite of Dartmoor was even subsequent to the carboniferous deposits. Mr. Wallace gives as the characteristic of Cornish granite, the admixture of schorl—of Scotch granite, hornblende. If this theory has any weight whatever, which I do not pretend to determine, we have here three distinct instruments for the discovery of truth as to the relative ages of our granite; the intrusion of granite into granite; the general configuration of its mass; and the nature of its chemical ingredients. Whether or not they are altogether sufficient to chisel out of these rocks a satisfactory and conclusive inference, I leave it in the hands of practical Geologists to determine. But I hope Mr. Carne will pardon me if I bring to his mind that he has heretofore observed much, and written well, on this branch of Geology; and that he would render an essential service to the science which he cultivates if he would again take up the hammer which has been so long on his shelf.

I closed the last Address which I had the honour to read from this place with a letter from Dr. Buckland, calling the attention of the Geologists of Cornwall to the evidence of ancient glaciers which had been discovered in some other parts of England, and in

Scotland, and which might possibly be found here, if sought after. Mr. Murchison, in the Address delivered by him to the Geological Society of London this season, has commented upon this letter, and has given it as his opinion, that it is futile to encourage the idea that such a search could be successful. I do not presume to arbitrate between such men; but as I have lately seen a tract of country in the west of Ireland, whose rocks present a striking appearance of the passage of hard substances over their surface, and the glacial theory offers one mode (perhaps not the right one) of explaining this appearance, I venture once again to bring the subject before you.

The physical conditions of that country are not very different from our own. The geographical and atmospheric circumstances are nearly the same: the rock appears to be a compact killas, not unlike our schistose killas, and probably of the same age; and the mountains, though higher than any found in this country, are not so much higher as to place them out of comparison with some of ours. But they are craggy, sharp, and hard; unlike the rounded knolls which our killas mountains generally show themselves.

I must warn you, however, that I am not a practical Geologist, and am conscious that I am stepping out of my ground in offering anything like original observation. Further, I am totally unacquainted with the country in which Agassiz and others have laboured in constructing their theory.

In many parts of the mountainous districts of Kerry, and the adjoining parts of Cork, the rocks on the sides of the mountains exhibit a most extraordinary appearance of smoothness, and are sometimes marked by grooves, and channels, running in the direction of the valleys which they skirt. But I saw nothing of those moraines, or loose fragmentary accumulations, which usually accompany a glacier.

The questions which force themselves on the mind of any one observing this strange-looking country are these: Is this smoothness the effect of weather? or of what Sir H. De la Beche calls divisional planes, or of planes of stratification? and, are these channels mere water-courses for the rain, and the result of its continual action?

To explain the full meaning of these questions, I think it best select one single case, and describe the circumstances as they ist; assuming that this one instance may be taken as a type of at occurs elsewhere.

The sugar-loaf mountain near Glengariff is a lofty peak, I supse about 2,000 feet high, sloping down to Bantry Bay; and along e shore there is a narrow plain, between the bay and the foot of e mountain. The plain is cultivated; but still the rocks show emselves at intervals down to the water's edge. All over the side the mountain, and on the plain, huge detached masses of rock, nilar in material to that of which the mountain is composed, are attered in great profusion. These often rest on the smooth surce of the living rocks; but are always, as far as I can judge, emselves rough, angular, and unworn by weather or any other ent. The strata are highly inclined, their strike being from the mmit of the mountain almost to the nearest part of the bay. ie smoothness on their exposed surface, whether edge or side, is ry striking; and this character prevails more or less over the ole flank and base of the mountain.

At first sight, one might impute this smoothness to natural disegration, the operation of weather; but the condition of the ulders seems to contradict this idea. They prove that the grayacke of which they, as well as the whole mountain, are composed, remarkably enduring, their edges being quite sharp, and the ocks themselves looking as if they had lately been broken off m the mass of which they once formed a part. It is clear then, at unless they have all fallen at a time comparatively recent (for ey are all in the same state), the rocks on which they rest must ve been subjected to some action which did not affect *them*, and hich consequently was not weather.

In a paper read at Cork, Professor Rogers, of America, after ying that all the more extensive revolutions of the earth's crust ve involved in some degree the agency of vast earthquake waves, scribes the smoothness and furrowed surfaces of rocks, both in urope and New Holland, as belonging to the action of these aves at different Geological epochs. Here is one way of acounting for the condition of the country which I am describing;

for the detached masses of rock may easily be conceived to have fallen from the summit, after the most violent action of the waves had ceased.

Against this hypothesis may be stated the fact, that I could perceive no such accumulations of rolled fragments, as must have occurred in the eddies of a vast and irregular wave.

Again, I have heard it conjectured that the smooth surface of the existing rocks may have resulted from the slipping away of the rocks which once covered them. But this smoothness is as apparent on the edges of the tilted strata as on the sides; and I do not comprehend how they could have been thus sliced off in the direction of no natural joint, by their own gravity, though assisted by the action of the force which raised the mountain.

Another explanation is the supposition that the mountain was at one time covered with ice, which pressed downwards into the plain in the manner of a glacier, and left a smooth surface behind it, which, from causes which have operated elsewhere, became afterwards exposed.

In the absence of moraines, the evidence is incomplete; still the whole appearance of the scene so forcibly suggests the idea of moving ice, that I cannot altogether reject the hypothesis because one material proof is wanting.

I do not, however, pretend to have a strong opinion on this question; which nevertheless, in all its phases, I think, touches us near enough to be interesting to Cornish Geologists.

Before I conclude this Address, which I am sorry to find has attained a great length, allow me once again to draw your attention to the capital which I hope the Society is about to create for the reward and assistance of those who will work for us. Two subjects suggest themselves to me as very proper for inquiry and for the use of such capital; and I offer them as illustrations of the manner in which the scheme which I have proposed may perhaps operate. It will of course remain with the Council to adopt or reject them; and if they should adopt them, to determine how they will treat them; whether by the offer of a premium to each, or by the tender of assistance to any person who will undertake to pursue the inquiries suggested by us.

Among the objects which appear to me to call for the careful attention of Geologists in this county, I would notice the altered or metamorphic condition of a large portion of our killas.

Sir H. De la Beche has described the extraordinary changes in the mineral character of the schistose rocks as they approach and come in contact with the granite and other igneous rocks. The labours of Mr. Peach have proved to us that our killas, where free from these chemical metamorphoses, is not so barren of organic remains as we had previously imagined. It strikes me that much valuable information might be obtained by patiently tracing those strata in which organic remains are to be found on our coasts, to their junction with the granite; noticing the progress of change of mineral character, and of the disappearance of fossils. Again, I think we shall do well to let it be known that we are willing to recompense any person who will give us a good account of the local relations of yellow and grey copper ore in our mines; stating the depth, and east and west position of these, with respect to each other, in a given lode or lodes; also, whether the containing rocks, or the lodes themselves, have the stain of iron-ochre; and whether the quantity of gossan has been apparently influenced by the nature of such ore.

THE THIRTIETH ANNUAL REPORT OF THE COUNCIL.

THE Council have at length the pleasure of announcing the publication of the fifth volume of the Society's Transactions, which is entirely occupied by Mr. Henwood's papers on the Metalliferous Deposits, &c. of Cornwall and Devon; and when the multitude of facts which he has brought forward, all from his own personal investigation, is considered, it will be admitted that, independently of other obstacles, which have not been few or unimportant, to its earlier publication, the labour and time necessary for an individual to explore so many of the mines of Cornwall, and several of them again and again, in order to test the correctness of his observations, must have included several years. It may now be stated with confidence, that, by this publication, a more extensive and particular description of the veins of Cornwall, as to their contents, metalliferous or otherwise, their bearings, intersections, connection with each other and with the rocks which they intersect, &c., will be laid before the Geological world than has ever before appeared. The number of large tables contained in the volume, the author having considered it necessary to bring the result of several observations into comparison by presenting them in a tabular form, together with the numerous plates, have greatly augmented the expense, and caused the price to be higher than that of either of the preceding volumes. To the public it cannot be less than thirty shillings; but to the members of the Society, for as many copies as they may wish for, the price of each will be twenty-five shillings.

The Council would draw the attention of the Society to a Geological Map, now in the museum, by Mr. Richard Thomas, of Perran, of the large district south of Helston, known by the name of Meneage, which has perhaps never before been surveyed so particularly; it is accompanied by about three hundred specimens of the rocks in that district.

The Council have again to notice the indefatigable labours
Mr. Peach, and also of Mr. R. Q. Couch, in the fossil Geology
Cornwall, especially their discovery of the remains of fossil fis
some of which were exhibited to the British Association at the
last meeting. The Society is indebted to them for a series of sp
cimens exhibiting those remains, the discovery of which forms
additional link in the chain which was supposed to exist betwe
a portion of the slate-rocks of Cornwall and those of the Devoni
system. The British Association having voted £10 to Mr. Pea
to enable him to continue his researches, the Council recommer
the addition of £5 from this Society for the same purpose, bei
convinced that its funds cannot be more usefully expended.

The Society has also been indebted for donations of simple a
fossiliferous minerals in the past year to several other zealous frienc
the particulars of which will appear in the report of the Curator.

This increase to the collection makes either a larger museum,
some rooms in addition to the present, almost indispensable, a
considerable part of the fossiliferous minerals remain in boxes
want of space in the museum to exhibit them. The Council wou
respectfully impress on their successors that another year oug
not to elapse without accomplishing this object.

The Council have again to express their regret that the premiu
offered by our President and other members of the Society, f
information of new and interesting facts connected with the min
have not drawn from the agents or from the miners the communic
tions which the Society has been anxious to obtain. They cann
doubt the willingness of the mine agents generally to promote t
views of the Society. The reason may perhaps be, that no partic
lar subject has been presented to their investigation. The Counc
would therefore suggest to the gentlemen who have kindly offer
the premiums, to connect them with researches and reports c
some particular points, to be submitted to the Council previous
the annual meetings.

By order,

L. R. WILLAN,
SAMUEL PIDWELL, } *Secretaries.*

Oct. 13th, 1843.

DONATIONS TO THE MUSEUM.

1. Sulphuret of tin, from Carn Brea Mines; slickensides; gossan or earthy oxide of iron through which runs a vein of stilpnosiderite; pinite from an elvan-course in Breage. By John Garby, Esq.
2. Copper ore from Shropshire. By M. Le Faux.
3. Saxicava rugosa and corals in limestone, steatite from Kynance Cove, specimens of altered slate, specimens of turbinolopsis, orthis, &c., from Padstow harbour, from the fossiliferous slate of St. Saviour, Polruan, and from Gerrans Bay. By N. Whitley, Esq., Truro.
4. Remains of fossil fish from Polperro and other neighbouring localities. By R. Q. Couch, Esq.
5. Remains of fossil fish. By C. W. Peach, Esq.
6. Pitchblende, from Wheal Providence. By Capt. Penberthy.
7. Sulphuret of lead in gossan; carbonate, sulphate, and black sulphuret of lead; compact supersulphuret of lead rich in silver; muriate of silver; black sulphuret of silver and copper, from the Sark Silver mines. By Mr. John Prince.
8. Calc spar with copper, from the serpentine formation near Pedn Boar Point. By the Rev. Edward Budge.
9. Granite, from Mont Maddo Quarries, Jersey. By Miss Mary Millett.
10. Arseniate of cobalt, and vitreous copper ore, from Wheal Trenwith, St. Ives. By Edwin Ley, Esq.
11. Vein of schorl rock in granite. By J. N. R. Millett, Esq.
12. Three hundred specimens illustrative of the geological structure of the district of Meneage. By Richard Thomas, Esq.

DONATIONS TO THE LIBRARY.

1. Transactions and Proceedings of the American Philosophical Society. By the society.
2. Journal of the Bombay Branch of the Royal Asiatic Society. By the editor.
3. Mr. Murchison's Address, delivered at the anniversary meeting of the Geological Society of London. By the author.
4. Bulletin de la Société Geologique de France. By the society.
5. Transactions and Proceedings of the Geological Society of London. By the society.
6. Reports of the Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne. By the society.
7. Report of the Truro Institution. By the institution.
8. Mr. Hunt's Essay on Thermography. By the author.
9. Professor Owen's Memoir on the Mylodon. By the author.
10. Memoires et Bulletin de l'Academie Royale de Bruxelles. By the academy.
11. The Mining Journal, from October, 1842, to October, 1843. By the editor.
12. M. Schwann's Memoir sur les Phenoménes periodiques de l'Homme. By the author.
13. Report of the 12th Meeting of the British Association for the Advancement of Science. By the association.
14. Tenth Annual Report of the Royal Cornwall Polytechnic Society. By the society.
15. Memoires de la Société de Physiques and de l'Histoire Naturelle de Genève. By the society.

16. A Geological Map of the District of Meneage, with an elevation view of the Cliff at Aust, in Gloucestershire. By Mr. Richard Thomas.
17. Plan of the Sark Silver Mines. By Mr. John Prince.
18. A Section of the west side of Clegga Head. By Mr. Whitley.
19. Annual Report of the Royal Institution of Cornwall. By the institution.

TREASURER'S ACCOUNT.

Receipts.	£	s.	d.
To Balance from last year	141	18	4
Subscription from His Royal Highness the Prince of Wales	20	0	0
Donation from His Royal Highness Prince Albert	10	10	0
Subscriptions received from Ordinary Members	58	16	0
	£231	4	4

Disbursements.	£	s.	d.
By Rent of the Society's House	31	10	0
Housekeeper	5	5	0
Taxes	2	18	6
Printing the last Report	5	19	0
Insurance	3	3	6
Advertising	2	19	6
Coal	4	3	0
Carpenter's work	2	14	5
Repairs and alterations of the Stove, Rain-gauge, Barometers, &c.	3	12	6
Sundry petty expenses paid by the Treasurer and Secretary in two years	5	16	6
Glazing and Painting	1	9	0
Stationery, Periodicals, &c.	9	2	2
Balance in favour of the Society	152	11	3
	£231	4	4

On the Fossil Fishes of Cornwall.

By CHARLES WILLIAM PEACH, Esq., F.G.S.,

CORRESPONDING MEMBER OF THE SOCIETY.

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the Address of Sir Charles Lemon at the last annual meeting, blished in the twenty-ninth Report of the Society, I find the lowing notice of a most interesting work, which I have since d with a most heart and soul sympathy with the author. The servation I particularly allude to, as connected with my subject, ll be found in the latter part of the quotation: "Within the last ew months a book has issued from the press, the title of which s, 'The Old Red Sandstone.' I think it ought to be in our ibrary; because, though no traces of the strange animals there lescribed have yet been found in this county, we live within their lomain." I feel it a high happiness now to be able to say with tainty, that we do "live within their domain," and that the re-ains of these "strange animals" have been found in our rocks.

I have long been of opinion that fish remains were embedded in e Cornish rocks, and at the meeting of the British Association : the advancement of science, held at Plymouth in 1841, I blicly stated that opinion. In my paper published in the enty-eighth Report of the Society, will be found, at page 16, der the heading of "Ready Money Cove," the following words: Possibly fishes;" and again, under the head "Polruan," at ge 18—"Portions of fishes, and specimens of a plant-like appearance."

At that time, the specimens I produced were very obscure; ill to me they were valuable, as connected with other forms hich I noticed in the rocks, and which, from their delicacy, and ie friable nature of the matrix in which they were embedded, ould not be removed. Thus the fossil fish of Cornwall were firmly

fixed in my mind, and in fancy floated before my eyes, and I felt a great desire to convince others that they existed not only in fancy, but in reality; but little did I think that the proof which I now have the pleasure of laying before the Society would be of such a triumphant character, or so complete, for complete it is; and I have the gratification of saying, that some of the most distinguished Geologists of the present day have pronounced the specimens produced beautiful and good ones, and that they belong to the fossil fishes of a very ancient date.

Some time since I received from the Messrs. Couch, Surgeons, of Polperro, in a letter, two or three small specimens of fossils, which they thought to be coral; and in my acknowledgment of the receipt, I gave it as my opinion that they were fish bones. I mention this in order to give those gentlemen the full credit of being the first to notice these organic remains in the rocks of their neighbourhood.

On the 20th of June last I visited Polperro, and, accompanied by Mr. R. Q. Couch, went into Scilly cove chang on the east side of the harbour, where, to my great delight, lay exposed before me a magnificent fish-bone bed, which extends from this spot to beyond Talland sand eastward, and from thence to the entrance of Fowey harbour westward.

These identical rocks are described in Messrs. Sedgwick and Murchison's paper, in the fifth volume (new series) of the Transactions of the Geological Society—"On the Physical Structure and "Older Stratified Rocks of Devonshire," as follows:—"At the "entrance of Polparrow harbour, the coarser quartzose beds are "overlaid by a beautiful rock, with a perfect transverse cleavage, "producing a fine striped slate. The beds dip north, at a great "angle, while the cleavage planes dip also north, but at a much "smaller angle. . . . . As the same prevailing northern dip "is continued to the mouth of Fowey river, it is obvious that the "beds above described are inferior to the fossiliferous group."*

I make this quotation to show, that notwithstanding the idea then entertained of the "inferior position of these rocks, from the

* Page 665.

upposition of their being non-fossiliferous, they must now be laced differently, for the fossils are found in those rocks with the transverse cleavage," and in the *slaty* rocks, from the top to the ottom of the cliffs, in the various layers exposed—generally on ıe under side: in some places they are very abundant. Most of ıem are of a beautiful shining jet black, and have that enamelled ppearance and granulous structure, mentioned both by Murchison nd Miller, as peculiar to the fishes of the "old red sandstone."

I have been able to identify the following as agreeing with those gured in Murchison's "Silurian Remains:" at present they appear nly in "mangled forms," but quite characteristic, and of suffi- ient plainness, so that, as far as *pictures* and *reality* can be com- ared, they are one and the same.

I find belonging to the "old red sandstone" part of the lateral orn of *Cephalaspis Lyellii* (Agassiz, Pl. i.); scales of ditto; por- ons of other descriptions of *Cephalaspis; Ctenacanthus ornatus* Agassiz, Pl. ii., fig. 14); scales, &c. of *Holoptychus nobilissimus* Agassiz, Pl. ii., bis.); with the shells *Bellerophon* and *Turnitella;* esides others not well defined.

Of the upper Ludlow rocks, there are, portions of the skin or ıagreen of the *Sphagodes* (Pl. iv., figs. 1 to 4); *Onchus Murchisoni* 'l. iv., figs. 10 and 11); also portions of teeth, and probably prolites.

Some of the above are also mentioned by Miller.

Besides these, there are several others differing in many respects. would particularly mention one which appears to be part of a ine: it is again covered with spine-like processes, which give the appearance of a crocketed pinnacle of a church tower. nother beautiful spine is most delicately striated: the striæ are ain divided, where a portion of the outer covering is removed.

Some of the scales of the *Cephalaspis* are round, others rhom- ›idal, and some like those described in Miller (Pl. vi. vii. & viii.) ı lozenge-shaped: there are also specimens, the scales of which, ıstead of being like any of the above mentioned, are long, and ave each end divided into a pyramidal form, locking alternately ıith the adjoining scales, into those forming the next row. Some ther specimens also differ: one which appears to belong to a rather

large fish is covered with tubercles in wave-like rows. These, with others, I have in my possession; and I have no doubt, if time permitted me to search closely, this list might be greatly extended. At Fowey, in Ready Money Cove, I have found part of an *Onchus*, and other remains; and at Polruan, fragments of bones, and portions of plants: I have also noticed portions of fishes from the Gribbon, near Menabilly, to Mellendreth beyond East Looe, but nowhere are they so abundant as near Polperro.

On the northern coast, in Lower St. Columb Porth, where I had a very short search, I got a portion of (apparently) an *Onchus*, and a tolerable specimen of a *Bellerophon;* this latter circumstance is interesting, as it shows that the fish-beds extend through the county.

I forbear to enter into a minute description of the rocks of Polperro, they having been so lately and accurately described by Messrs. Murchison and Sedgwick, and still later by Sir. H. De la Beche, in the Ordnance Geological Survey. I shall only remark that they contain great quantities of volcanic matter, the eruption of which is supposed to have been the cause of the sudden destruction of the tenants of the ancient seas.

Although my business is only with the fish remains, I cannot resist the temptation of mentioning that at Giggan Cove there is an extensive fault, which has thrown the strata into great confusion: here there is a large vein of limestone of a greyish colour, exceedingly hard and compact, several feet in width, which contains portions of fishes, and specimens of the *Bellerophon*, &c.; it shows itself again at Old Island, and Lake Rock, where it is several yards in width, and encloses great quantities of nodules, traversed by veins of calcareous spar very much like Septaria: here the organic remains are very indistinct: from this spot the vein may be traced across the beach to Rotterdam, into the cliffs on the eastern side of Talland Sand.

Notwithstanding the discovery of the one thing (viz., fish remains) deemed to be needful in order to our having "a name and "a habitation" in the Geological scale, we are still, it seems, doomed to be nameless; for although Mr. Murchison, at Cork, said "that these fish remains appear to belong to the upper silurian, "the oldest rocks in which the remains of any vertebrated

"animals have been discovered, and that they occur in rocks "forming the axis of South Devon, which he had always con- "sidered the oldest in the country"—and Mr. Phillips regarded them "as equally related to the carboniferous and silurian forms, "and probably belonging to an intermediate position parallel with "the cornstones of Herefordshire"—we are still to remain in an unsettled state. When men so high and celebrated in the science of geology shrink from the task of christening our rocks, it would be presumption in such an humble individual as myself to attempt to do so: we must therefore "bide our time," working on in right good earnest, and endeavouring to bring forward such evidence as will prove our true position, and force them to give *positively* what they now advance so *cautiously*. Leaving the matter in their hands for the present, I shall return to my home with a full determination on every opportunity with "pick and gad" to rip the rocks and exhume the long-entombed remains of by-gone ages, and place them in situations where they may be viewed, and made use of for the benefit of science; and should I be fortunate enough to bring forward what may still further advance the tide of truth, it will add to the pleasure I have so often experienced when a new wonder has been laid open before me; and as I have the happiness of knowing that new and useful helpmates are in the field, with whose labours I am delighted, I can only say, "Go on; let us neither rest "nor be weary, until we have attained our end."

A Sketch of the Origin of Mining Laws in Europe.

By the late JOHN HAWKINS, Esq.

Communicated by Sir CHARLES LEMON, Bart., M.P., F.R.S., &c.,

PRESIDENT OF THE SOCIETY.

The following remarks were sent to me by Mr. Hawkins, when I had a work in hand which was afterwards set aside. I allude to the time when the project was on foot to restore the Antient Stannary Courts, and to make such alterations in the laws which they administer as the present state of mining might require. It occurred to me that some knowledge of the laws of other countries might then be of use; and Mr. Hawkins was kind enough to assist me in acquiring that knowledge, by giving me, as a foundation, a sketch of the mining laws under the Roman Empire, and at subsequent times, which he had prepared for another purpose, but not published. Everything from his pen is valuable; and as I had his full permission to make use of his remarks as I thought proper, and have now the sanction of his family to the same effect, I do not scruple to lay before the society, in his own words, this very interesting survey of the antient codes from which the present mining laws of the different countries of Europe have sprung.

Charles Lemon.

It being expedient to observe some order in the arrangement of this information, I have made choice of that which is suggested by a chronological view of the subject, and this has made it difficult for me to avoid throwing the whole into an historical form, although in connecting the facts before me, you may be disposed to think that I have taken some liberties, which it was by no means my intention to do.

I presume it is not your object to go farther back into the history of mining than the period of the Roman Empire; but it is of no small importance to your inquiry, to ascertain in what light mines were considered at that period, for in the form of government which the Romans established in all the countries which they had subdued, it is not improbable we may still recognize some features of that which now subsists.

The rich mines of Spain, Thrace, and Upper Egypt, when those countries fell into the hands of the Romans, appear to have been regarded as the property of the state, and were farmed out like most other sources of public revenue. They were chiefly mines of gold and silver, the labour of which was performed by slaves and state criminals.*

At a later period there is reason to believe that the obligation of working in the mines was imposed on the inhabitants of the districts in which they were situated, *glebæ et metallis adscripti*, as is the case at present in Siberia and the Turkish empire. This was the condition of the mines in Thrace in the reign of the emperor Valens, when the miners abandoned their works, and joined the victorious Goths.†

Trajan instituted a corporation of mining adventurers, under the denomination of *Collegium aurariorum*, for working the gold mines of Dacia (vide Gebhard's "History of Hungary," where the fact is proved by some Roman inscriptions); and Valentinian the First gave permission to every one to open new mines (of gold and silver?) on consideration of his receiving a certain portion of their produce.‡

As early however as towards the end of the Republic, there are even indications of private persons having been the proprietors of mines;§ and there is reason to believe that this was the case at a much later period.‖

The revenue which was drawn from this source, as well as from salt-works, rivers, forests, and quarries of marble, was appropriated to the Fisc or public treasury, and placed under the administration

* Diod. Sic. v. 28.

† Cod. Theod., lib. 15, and x. titl. 19. Ammianus Marcellinus, xxxi. Cod. Theod. de Metallariis.

‡ Vid. Tit. Cod. Justin. de Metallis. § Strabo, xii. p. 221.

‖ Essai sur la Mineralogie des Monts Pyrenees, p. 243.

of the Comes Sacr. Largitionum, subject to whom in the eastern provinces of the empire was a Comes Metallorum. But these were merely officers of the revenue, and appear to have had no jurisdiction over the mines: nor is there reason to suppose that any code of mining laws was ever enacted by the Romans.

How long this impost on the produce of mines continued to be levied we know not; it probably subsisted until the mines partook of the general ruin of the Western Empire during the irruptions of the barbarous nations. The mines being then abandoned, and the Imperial Government at an end, no revenue could have been raised from this source during a period of considerable length.

But when Charlemagne had established something which in regard to its form and extent resembled the old Roman Empire of the west, and it accorded with the policy of the Papal See to sanction the delusion of its revival, there were not wanting some law-writers who supported the claim of the German Emperors to all the Royalties (regalia) which had belonged to the Roman Emperors, among which, as they pretended, was the tenth of all the produce of mines, although it may be observed that Frederic the First was the first who attempted to establish this right in its full extent; Charlemagne having exercised it in respect to such mines only as were situated in his own domains.

Although the tenth of the produce of mines was all that could be fairly claimed on the hypothesis of an uninterrupted succession, yet the mines themselves began at this time to be considered as fiscal property, and they were disposed of in various imperial grants of feoffment to the princes or great vassals of the empire, this assumed right being based on a false interpretation of the Roman law, although it plainly appears that Justinian had regarded the mines, according to the spirit of the more ancient Roman law, as private property, *ad fructus fundi*, the use of which was unrestricted. In fact, his pandects allow of no other interpretation. We learn however from the Codex of Justinian, lib. ix., tit. 6, that there were some ordinances of preceding emperors by which the right of opening mines was granted on the consideration of a certain impost payable to the public Treasury; and although these ordinances are properly to be regarded as exceptions to the general

rule, applied to particular cases, yet some law-writers have nevertheless deduced therefrom an extension of a right of royalty over all mines, following in this respect the doctors of the Bolognian school, who in their time, by means of this interpretation, flattered the ambitious views of the King of Lombardy and Rome, as far as regarded the rights and prerogatives annexed to the Imperial dignity; and the establishment of this doctrine led to the most important modifications of the public law of Germany during the middle ages;* and one of the changes which was thus produced, according to the opinion of Hullmann in his history of the origin of royalties (regalia) in Germany, was the assumption of the imperial right to the royalty of mines, which till then had been exercised as a demainial right, and this in particular instances only, prior to the reign of Frederic the First, but which that emperor first established under the new title of regalia, or royalties, throughout Germany. In short, Hullmann has fully shown, that until the close of the 11th century, in all the instances of mines belonging to that period, which are to be found in public records, and even those which rest on authorities of a later date, *the property in mines was invariably vested in the owners of the soil.*

To this period of freedom in the history of mining may be traced the mining laws of all the states of Germany. These laws were originally the work of free mining associations; suggested by circumstances as they arose; recorded at first in the memories of the old, afterwards digested and committed to writing, and finally revised and confirmed by the several princes who ruled over these states.

The sort of customary or prescriptive legislation here alluded to was not disturbed by the interference of any prince or emperor during the period above-mentioned; for although Charlemagne may have caused the mines in his own demesne to be worked on his own account, as there is reason to believe,† and the Emperor Frederic the First laid claim to the royalty of the mines in all Germany, yet the mining laws which were enacted in those early times were not

* Cons. J. St. Putteri specimen jur. publ. et gent. medii ævi, De instauratione Imp. Roman. sub Car. Magn. et Otton. Magn. facta, ejusque effectibus.

† v. Capitular Car. Mag. de villis, c. 62.

altered or set aside by any positive or direct interference of the emperors; and the German princes forbore to meddle with them till a much later period; when some of these princes, being formally invested by the emperors with the feudal sovereignty over the countries which they had governed in a different capacity, while others had arbitrarily possessed themselves of these rights, they naturally felt a more direct interest than they before had in the management of the mines; and the manner in which they then interfered in mining concerns, as legislators, plainly shows what was the original constitution of these mines: for instance, the oldest written laws of the different states of Germany, on the subject of mines, bear evident marks of the unwritten law of custom or prescription which had previously existed, as well as of their having been collected and compiled before they were ratified and published by these princes.

The most ancient of these were the mining laws of Iglau, a mining town on the confines of Moravia and Bohemia, which are still preserved in some of the public libraries, and which have several times appeared in print. These laws received the confirmation of the King of Bohemia and of the Margraf of Moravia in the years 1248 and 1253; but not before they had been considerably modified and adapted to the feudal form of government which then prevailed. They have served as the basis of all the mining codes which were subsequently compiled for the use of the various states of Germany. It has been remarked that they are drawn up for the most part in a casuistical form, being confined to the decision of particular cases, without reference to the reason of that decision; therefore, it is only by the collation and comparison of many such cases, that we can collect what were the principles of jurisprudence on which these decisions were founded.

The royalty of mines was unquestionably exercised at a period of the history of Europe comparatively early, as a feudal or usufructuary right, although the fiscal exaction of a tenth of the produce of mines may be of an earlier date; for it appears, as I have already stated, on the hypothesis of an uninterrupted continuation of the rights and prerogatives of the Roman emperors.

At present this right of royalty enables the prince who holds it, either *in capite* or by substitution, to open mines in the lands of any of his subjects; but this right does not extend over all minerals whatever, and the rule is, moreover, different in different states: for instance, in Bohemia and Moravia, it extends only over mines of gold or silver; but in most of the Prussian provinces, to almost all minerals whatever.

It follows from this that the landowners, in most cases, are not at liberty to open mines in their own grounds, without the consent of the sovereign. They are nevertheless admitted to a participation of the produce of such mines, and this in certain proportions, which vary according to the nature of that produce, and the particular law of each state: for instance, in some countries, the tenth is equally divided between the prince and the landowner, while of some minerals no portion is claimed by the former. The tenth is likewise modified according to the circumstances of the mine, and sometimes it is wholly relinquished until all the costs are paid.

That the royalty of mines might be rendered more profitable to the sovereign, it was judged expedient at a very early period to confer on miners certain privileges and immunities, which had the effect of encouraging their exertions. Thus all persons were allowed to search for mines wherever they pleased, provided they did no wilful injury to the landowners or occupiers. On the discovery of ore, the first finder, on applying for a lease or sett, obtains it without difficulty, subject however to proper regulations and restrictions. The ground is measured, and in the earliest times the measure was a very limited one, until the period when the deeper adits were driven: it was then judged expedient to enlarge it.

The facility with which the right of opening a new mine is obtained in Germany, reminds us of the Cornish tin-bounds; but there is no other point of resemblance, for the right of pitching bounds in Cornwall is limited to particular lands, and numerous obligations are imposed on the German miner, with a view to secure a fair and effective working of the mines. In Germany, moreover, the measure of ground which is granted to a miner is adapted to the course of the lodes, and is consequently long and narrow; but in Cornwall the bounds are limited by no such rules,

because when they were first instituted, the stream-works appear to have been the sole objects of mining speculation.

As the feudal law was established in England by William the Conqueror, it may be supposed that in Cornwall as well as elsewhere it surperseded all other laws, and it may therefore be inferred that all traces of anterior laws in that country must have disappeared. Nevertheless I cannot help suspecting, that had the law of property in Cornwall been wholly changed by William the Conqueror, we should have found a more extensive signification given to the right of royalty as it regards our mines, and that the free right of searching, as well as the claim of the first discoverer to a grant or sett, would have been as firmly established there as in Germany.

The power of the Duke of Cornwall in this respect is a very limited one, and the natural rights of the landowners throughout a great portion of the Duchy are untouched. They are still *Domini fundi*, and this is a state of things which, in regard to its origin, carries us back to a period antecedent to that of the Conquest.

On Diluvial Action, as exemplified in the Gravel-beds and Sienitic formation of Crousa-Down, in the Parish of St. Keverne.

By the Rev. EDWARD BUDGE,

MEMBER OF THE SOCIETY.

It is well known that this county abounds in evidences of the fact, that at some ancient period its surface has been greatly modified by the action of a disturbed body of water. The huge blocks of stone which lie scattered about over all our downs, and the beds of apparently water-worn gravel which are heaped up in many places, are familiar instances of some of the extraordinary effects that have resulted from an inundation or flood which has left behind it traces of the power and magnitude of its operations. The spot to which this paper refers is one which has hitherto attracted but little observation; and from its lying so much out of the track of tourists, this can scarcely be a matter of wonder. Professor Sedgwick, in his account of the Lizard district, has but barely noticed it; and De la Beche, in his Report, has only given a few lines descriptive of its general features: he considers this as possibly belonging to an epoch anterior to the production of the valleys of the district; and in alluding to the uncertainty of its geological date, he remarks that "this patch of gravel is perfectly isolated, occupies an area of "about half a square mile, at a height of about 360 feet above "the level of the sea, and resembles no other accumulation of "superficial detritus within considerable distances."

In making a few observations on this deposit, my design is to bring it more under the general notice of those who may visit the Lizard district for scientific purposes: and I venture also to think that I shall be following out the track pursued in my two former papers, by noticing more at length some points connected with the locality that I more particularly refer to, which may be worthy of

investigation by all who are interested in the monuments that still remain in our county to attest the nature or extent of former geological changes.

Crousa-Down is an extensive piece of nearly level ground, having a very slight declivity towards the south, and is just on a level with Goonhilly-Down, the Dry-Tree, the highest part of the latter being only about 7 feet higher. On the eastern side, Roscreage Beacon is a point of land a little more elevated, being 380 feet above the level of the sea. About a quarter of a mile distant from the road leading to Coverack are the beds, or sand-pits, as they are familiarly termed, to which I refer. They consist of numerous layers of fine or coarse yellow gravel, alternating with quartz pebbles, but in no very determinate order. These pits having been excavated during many years for different purposes, they exhibit sections to the depth of 10 or 12 feet in some places, and there is reason to believe that they extend downwards much deeper, as beds of a similar though inferior kind have been opened and worked at a lower level on the same Down. Over these beds is an accumulation of black peaty soil of about six inches deep, and the surface, where recently exposed by the cutting of the turf, looks as if it were strewed over with small fragments of quartz, having the same sharpness and freshness as if they had been recently broken and scattered about. In this they present a strange contrast to the rounded pebbles which are below them, looking as if they belonged to a different order of causes, by which in the one case the same substance was rounded, as in the other, was only broken up and splintered.

The evident conclusion to which we are led by looking at these deposits is, that they are the *débris* of some considerable portion of quartz, from which alone pebbles of this kind could have been derived. If they were not reduced to this state of comminution and roundness on the spot where we now find them, they must have been brought here previously to the period when the neighbouring valleys were formed; for it would be impossible to suppose that a mass of this nature should have been rolled up over the hills, instead of being deposited in the valleys that occur in the vicinity of this spot.

Two subjects of inquiry here present themselves; first, From what source have these pebbles and their accompanying sand been derived? and secondly, Can any causes be assigned for their accumulation in this particular place? The first of these inquiries is naturally connected with the quartz formation of this neighbourhood. A little south of the Nare Point, masses of this substance rise a short distance beyond the cliff, and as they are almost directly in the line of strike with the same rock at the Dodman Point, and are precisely the same kind of rock (as I have found by examining specimens sent to me by Mr. Peach), there is reason to conclude it to be a continuation of what we may suppose was once the nucleus of the greywacke and conglomerate formations which enclose it on either side. It is easy to trace this rock stretching from the Nare in a north-westerly direction for several miles. It may be seen occasionally cropping out on the sides of the valleys, and large blocks, economically used as fences, supply a certain index of its course. The largest masses of it are seen at the place I have mentioned near the Nare, and in a deep gorge south-west of Carne, in St. Anthony, where it is at least ten feet in width. In some cases the colour of this rock is white, but frequently it changes to grey, and in the darker shades of that tint it takes the form of a coarse siliceous sandstone. This is the case in the valley leading up from the estuary towards Manaccan. It may here be observed to pass almost by a gradual transition into some of the varieties of conglomerate with which it stands intimately associated. It is therefore no improbable conjecture that this rock, at the period when it was broken up, contributed by its detritus to supply a portion of the fragments which were afterwards accumulated, in the form of rolled pebbles and gravel, in the deposit now under consideration. I do not, however, imagine that more than a portion of it has been thus supplied. The pebbles would have been of larger size, and of greater variety of colour, had they all come from this source. The generality of them are white; some of them as large as a man's head; but, for the most part, they do not exceed two or three inches in length, and most of them are still smaller. Their forms are also very irregular: many look like small flints, and are excessively hard. These I should refer to the great quartzose

formation just mentioned; but the rest I am disposed to consider as the result of much smaller veins, which are characteristic of the greywacke and its kindred formations. All these appear to have undergone extensive degradation and abrasion in different parts of the district, since the period of their first consolidation. The conglomerate of the Nare contains numerous veins of quartz which, like those in the greywacke-slate formation, appear to have been formed by siliceous infiltration, which may account for their being somewhat loosely aggregated in their structure; a circumstance which, combined with oxide of iron percolating through the crevices of the rock by the action of water, renders them extremely liable to disintegrate, and fall out from the mass to which they belong. This circumstance facilitates the ruin of such rocks. We cannot visit any of our beaches in the neighbourhood of the slate formation without being struck with the abundance of white quartzose and other pebbles with which they are covered; a circumstance which especially leads to the conclusion that quartz veins of the class which are usually observed intersecting the schist rocks, were the source from whence the pebbles found in the Crousa-Down gravel-beds were in all probability derived.

To resolve the second question proposed respecting those beds may be a more difficult task. The only inference we can draw from the fact of their being accumulated here in such considerable quantities is, that there must have been particular circumstances, either in the drift of the currents, or in the nature of the ground, which were favourable to such a deposit. To this we must superadd one requisite condition of the problem; viz., rocks of a class abounding in such veins, which could not have been very remote; and indeed we may reasonably think that the space now occupied by our valleys was then filled with such rocks. Now it is easy to conceive that there may have been before the period of this deposit some considerable hollow or depression here, which would have acted as a sort of funnel to absorb the *débris* that was previously washed about in a looser and more dispersed condition. There is nothing to indicate that a lake or estuary once existed on this spot, or we might suppose that this, in combination with a powerful river, were the agents in collecting this mass of gravel, and depositing

the sand and pebbles in the state of beds, as we now find them. The present condition of the sienitic formation will perhaps serve to countenance the opinion, that an extensive excavation of the strata must have here taken place before the period of the gravel deposit. Whatever were the circumstances under which these rocks originated, they must at the first have formed a continuous mass; but they are now, for the most part, in a state of total wreck and separation. The whole line of country, from Porthoustock to Gwinter, a distance of four miles at least, presents a broad band of scattered boulders of that variety of rocks which from its excessive hardness is here termed iron-stone. Mr. Majendie considers this rock to consist of felspar, hornblende, and diallage; but I apprehend that quartz also, in an inferior degree, enters into its composition. If, then, we suppose that these blocks are the remains of a high ridge of sienite rocks, it will be obvious, that when these were swept away from their ancient position, a deep chasm must have been the necessary result of this displacement. It is evident to an observer that none of these blocks to which I refer are *in situ*, unless we suppose that the beds from which they were torn lie buried underneath the deep covering of superficial *débris*, which in most places hides all traces of such beds from view. To a certain extent this probably is the case, for a little to the west of Crousa-Down there is a stratum of what is commonly termed *marle*, but which I found on examination to be sienitic rock, of precisely the same character as the boulders on the Down, only in a state of entire decomposition, which renders it, after a short exposure to the air, fit for agricultural purposes, and makes it a most fertilizing manure, from its containing a due proportion of those earths and alkalies which are so essential to vegetation.

It is curious here to remark (though it would be beside my purpose to explain) how, by a chemical process which is admirably adapted to serve the interests of man, the same rock which we see lying over the surface in unwieldy blocks which encumber the soil, and are remarkable for hardness and intractability, may, by the softening agencies which time and Nature have at command, be made available for the interests of the agriculturalist. I may mention the fact that the owner of these marle-pits (as they are called) has almost a

mine of wealth in such a possession. Thousands of loads are, and may be, sold as manure, and yet, from the depth of the deposit, there is little fear of impoverishment by that which would generally prove a ruinous expedient.

In looking, however, at one of these quarries which I noticed near Trelan, I am led to entertain an idea that this rock, as well as granite, to which it bears a considerable resemblance in some points, was originally formed of different degrees of solidity, and that the harder parts, which we now see scattered about in the form of tors and boulders, are only as it were the kernels of the original mass; and that these, from a more perfect crystallization, or from some other chemical circumstance affecting the compound, have remained, and are still likely to remain, impermeable to atmospheric influences. I am led, therefore, to conjecture, that to some such cause as this we may ascribe the destruction of these masses of sienitic rock which once occupied the crest of Crousa-Down; and I imagine that the marle-pits which I have just noticed are only the outcropping of its deeper beds, which have been more slowly undergoing the same process of decomposition and disintegration, as that which led to the overthrow and dissolution of the upper strata.

We have only then to suppose diluvial action to have been brought to bear upon masses of rock, which were previously disqualified to resist its violent operations, by being but imperfectly consolidated throughout their entire substance. The effect of such an attack of the waters would be to tear up and disperse large portions of them, and in this destruction many of the neighbouring rocks would inevitably share. It is easy also to conceive, that watery disruptions from without may not have been unaccompanied by internal disturbances of a volcanic description.

Upon the whole view of the case, it is hardly possible to avoid the conclusion, that this part of the Lizard district was the focus and centre of those destructive agencies which have strewed the neighbouring Downs with the fragments of ruin and convulsion. The gravel-beds of Crousa must, I imagine, have owed their origin to a period when, by the operation of a terrific power which baffles all conception, huge portions of rock were ejected from their more ancient position, and rolled about among fragments of quartz, upon

which they acted as hammers, to pound them into sand, or to shatter them into fragments. During this season of strife and elemental war, currents would have taken the form of whirlpools; and it is to this cause perhaps that we are to trace the filling up of such a cavity as that we have here supposed, with the floating detritus. Successive agitations and upheavings of the contents of these gravel-beds, after they were once accumulated, would give to the whole that appearance which they now have, of sedimentary substances deposited under circumstances of alternate tranquillity and disturbance. Following out this speculation, I am induced to think that it was at this period that the Raised Beaches of Coverack and other localities along the coast, as well as the tract termed the Lowlands, which I described in my last paper, became invested with the fine covering of sand which now lies over them. This I consider to be the washing down of the finer portions of the scienitic, conglomerate, and hornblende rocks, reduced to a finely comminuted state by diluvial action.

Upon the whole, I conclude that the several circumstances to which I have adverted will suffice to throw some light upon the origin of a deposit which must be allowed to be one of an almost unique character in our county. The facts which I have stated seem to me to harmonize well with one another, and to furnish a most important monument of the revolutions of the earth's surface in past ages. A testimony is also here afforded to the theory of those geologists who have supposed that the range of diluvial currents which swept over the earth at some former period was from north to south; for this is the general direction in which we find the blocks of sienite distributed over the slopes of Crousa-Down. There are blocks, however, of the same stone scattered over Goonhilly-Down in a direction considerably northward and westward of what must have been the limit of the sienitic formation, a fact which, with some others, may serve to show that there was also a reflux as well as a direct current.

If, then, we ascribe to the agency of water the gravel deposits in question—the scooping out of most of our valleys—the levelling of the Goonhilly plateau, and its envelopment with a thick coat of clay derived from the breaking up of the argillaceous strata of the

neighbourhood, and if we add to this the distribution of our stream-tin and manaccanite through the water-courses where they are now found, we shall have a list of diluvial results, all of extraordinary character, and effected within the limits of our county, at one and the same period. It would be disingenuous to conceal the fact that I conceive the great Deluge described in the Book of Genesis to be adequate to explain all such phenomena as those to which I here advert. It may be the fashion of the day (at least it is one of the curious phases of modern science) to pass rather slightingly over an event, upon which the older theorists rested the whole weight of their geological systems. That event which was used formerly to explain everything, is now too apt to be treated as if it were capable of explaining nothing. To avoid these extremes, seems to me to be doing only justice to a science which needs not to encumber itself with fresh difficulties by keeping out of sight one of the most mighty changes which the earth's surface has ever undergone;—a catastrophe, the evidences of which will always be valuable, as they serve to link together divine and human knowledge into one harmonious chain; and impart to scenes that are apparently barren and uninviting, something of that high interest which must attach to the theatre of man's primeval history.

On the Relative Position of the Yellow and Vitreous Sulphurets of Copper in the Lode of Pembroke Mine.

By RICHARD TAYLOR, Esq., F.G.S.

MEMBER OF THE SOCIETY.

I am induced, by what fell from the President during a conversation with him respecting the local relations of the yellow and grey copper ores in the mines of this county, to offer this brief notice of the very striking difference in the character of the ores contained in the lodes which were formerly worked in Pembroke mine, and now in Boscundle, one of the Charlestown mines, which I have observed as the workings of the mine have advanced westward.

In the eastern part of Pembroke, which is near the cliffs of St. Austell bay, the ore was a strong yellow sulphuret; in the central portion of Pembroke mine, black and grey ores occurred as well as yellow ore. In the western part of the mine, the black and grey ores prevailed, although the mine still produced some yellow sulphuret, particularly where it was worked to the greatest depth.

In Boscundle, which is considerably further west, on the course of the same lodes, some very rich bunches of grey copper, accompanied by black oxide of copper, have been found at shallow levels. Associated with these ores were also yellow sulphurets, containing an unusually high produce of copper, and being thickly coated with grey and black ore. In this locality, however, a still more remarkable change occurs, in the presence of tin in considerable abundance, in some places constituting portions of the lode distinct for those containing copper, but in others intimately mixed with the richest portions of copper ores.

The further progress of the works westward has proved the almost entire diappearance of copper from these lodes, while they have become regularly productive of tin.

The remains of some ancient workings, at a short distance further

west than those recently made, and although still in killas, being on the flank of the granite hill, on the summit of which the celebrated Carclaze tin mine is situated, show no trace of copper, but present the mineral characters which are common in the tin lodes of that district.

Parallel to the lodes which I have here noticed are, on the north-east, Crinnis lodes, and on the south, the very large and rich lode which formerly produced copper in such large quantities in Great Crinnis mine, situated on the cliff of St. Austell bay, and has in later years been extensively worked for tin in Charlestown mines.

I have good reason to believe that changes in the metalliferous contents, very similar to those I have described as occurring in the Pembroke lodes, characterize those which are parallel to them in this locality, but I have not had the same opportunity of tracing them in their whole course.

I may however notice that so completely has the Great Crinnis lode changed its character as it has been explored westward, that in the Charlestown mines I have not found it to contain any copper, except in a few hard specimens, in which very thin flakes of native copper have been found curiously interspersed in hard tin-stone.

I regret that the haste with which I have been obliged to prepare this brief sketch has not allowed me to do more than to notice generally some of the most striking features of this case, as I am aware that, to be of any value, many and precise details are requisite, descriptive of the variety in the earthy mineralization of the veins and of the disturbances in their course occasioned by cross-courses and slides, which in this case are very considerable, as well as of the character of the including rocks.

There is one circumstance which it is right that I should particularly mention, as we are taught by Mr. R. W. Fox to consider it of importance in the explanation of the changes which may have occurred in the metalliferous contents of lodes subsequently to their original deposition; viz., that the killas in contact with those parts of the lodes which contain the grey and black ores, are stained a bright red colour. This is remarkably the case in parts of Pembroke mine, and in Boscundle, but not invariably so; and I am inclined to think that this staining does not extend to any great depth from the surface, even although the veins continue to contain grey ores.

An Account of the Sark Mine, in the Island of Sark.

By Mr. JOHN PRINCE,

ASSOCIATE OF THE SOCIETY.

This mine is sunk 70 fathoms below the deep adit, and levels are extended 150 fathoms east of Le Pelley's shaft, and 70 fathoms west of Sark's Hope, under the sea. The lode varies in size from 3 to 12 feet, bears nearly E.N.E. and W.S.W., and dips, on an average, 10 degrees northerly. The rock which it traverses is a very hard sienite, except near the lode, where it is decomposed, and in some places chlorite (peach) is found. In these decomposed sienitic and chloritic rocks are numerous steatitic joints, and veins of massive and crystalline carbonate of lime, peroxide of iron, and beds of oxy-hydrate of manganese.

The matrix of the lode consists of fragments of the strata, carbonate of lime, milk, rose, and brown quartz, red, green, and white felspar, and in some places hornstone (capal). The lode, as far down as 40 fathoms below the sea, contains an abundance of brown earthy iron ore or gossan (which, however, is not found in the eastern part of the mine), with nodulated, radiated, argentiferous, arsenical, auriferous, and white and magnetic iron pyrites (mundic). The ores produced are the muriate and sulphuret of silver, and sulphuret of lead, combined more or less with other ingredients hereafter to be mentioned.

The following circumstance occurring in this mine appears to be peculiar, and will perhaps be read with interest.

No silver ores (with the exception of a few crystals of ruby silver) have been found uncombined with lead west of Le Pelley's shaft; whereas the lode east of the shaft contained deposits of rich silver ores without any lead.

Those places in the shallow adit, numbered 1 on the section, produced crystalline carbonate, sulphuret, and sulphate of lead; but the spot numbered 2 in the same level east of the shaft, contained none of these minerals, but muriate of silver (see specimens): this muriate continued to the deep adit level, where it was replaced by black sulphuret of silver and copper, with disintegrated iron pyrites (sandy mundic) not chemically combined. This ore reached the 30 fathoms level, below which we have found sulphuret of silver chemically combined with the sulphurets of copper and antimony, without any pyrites.

The following minerals have been found in the deeper levels of the western part of the mine; viz., sulphato-tri-carbonate of lead, sulphuret of lead, super-sulphuret of lead, black sulphuret of lead (rich in silver), antimoniferous galena, and granular galena. These ores contained from 20 to 85 per cent. of lead, and from 30 to 120 ounces of fine silver to the ton of ore.

The following are my analyses, which will show the relative contents of the ores taken from the undermentioned places:—

No. 1.—Ore from shallow adit west of Le Pelley's shaft, marked 1 in the Section.

Carbonate of lead	30, 50
Sulphuret of lead	20, 38
Silver	0, 12
Carbonate of lime	4, 00
Peroxide of iron	3, 25
Silex	41, 75
	100, 00

No. 2.—Ore from shallow adit east of Le Pelley's shaft marked 2 in the Section.

Muriate of silver	10, 00
Peroxide of iron	1, 75
Carbonate of copper	0, 25
Carbonate of lime	4, 00
Alumina	8, 00
Silex	76, 00
	100, 00

No. 3.—Ore from 50 fathoms level, 40 fathoms west of Sark's Hope shaft.

Lead	65, 00
Silver	0, 25
Antimony	4, 75
Sulphur	12, 00
Lime	12, 00
Carbonic acid	4, 30
Water and loss	1, 70
	100, 00

No. 4.—Ore from 50 fathoms level, 10 fathoms east of Le Pelley's shaft.

Silver	9, 50
Copper	8, 75
Antimony	5, 25
Sulphur	5, 50
Iron	2, 00
Silex	67, 00
Water and loss	2, 00
	100, 00

It is to be remarked, that we have no cross-courses, dykes, or flucans, in any part of the mine, to affect the change to which I have adverted: there is however a manifest difference in the matrix of the lode, as also in the contiguous rock, which I now purpose briefly noticing. "I would first observe that the *gossans* in the western part of the mine contain carbonate of lead, with minute grains of the sulphuret, with which a small portion of silver is combined: in these gossans we frequently find nodular iron pyrites, exceedingly hard, which when broken shows a beautiful radiated appearance: fragments of quartz are to be seen here; and on both sides of the lode a considerable quantity of hydrate of manganese. The rock here (in the shallow adit) is a decomposing sienite, which continues down to the 10 fathoms level: from thence to the bottom of the mine chlorite appears, which is traversed by numerous small veins of peroxide of iron and carbonate of lime. It is remarkable, however, that in the *cross-cuts* which have been extended a few feet on both sides of the lode, we have invariably found a hard sienitic rock containing an excess of hornblende, but not the least appearance of either iron or lime.

The lode below the 10 fathoms level consists of chlorite, carbonate of lime, and felspar, with felspar-clay (prian) on the *hanging* wall, and more or less ore on the *foot* wall.

The gossans in the shallow adit east of Le Pelley's shaft contain blue and green carbonate of copper, with muriate of silver, &c. I have frequently seen native sulphur in this part of the mine. This I have also seen in the roof of the level, over the bunch of ore. (See No. 4 in the section.)

There is no material difference respecting the quantity of iron and lime throughout the lode; but a greater abundance of friable (sugary) and angular quartz of various colours is found here, with conglomerated and other earthy matter. *Here is no felspar-clay*, and the ores are formed on the *hanging wall.* The rock is a sienite containing an excess of reddish-brown mica, and hornblende evidently in a decomposing state. It is not traversed by any of those veins so numerous in the western part of the mine.

Remarks on the minor Fractures of Rocks, illustrated by Specimens.

By Mr. NICHOLAS WHITLEY.

It is a question of some interest, whether the minor fractures of rocks have been produced in a similar manner, and are analogous to those which exist on a large scale. The heaves, as they have been called, in the small strings of tin at St. Agnes, have long been known. Sir H. De la Beche appears to think that there is no analogy between these and the larger dislocations; these "heaves," he says, "being nothing but numerous *small fragments of slates*, "the results of the minor fractures produced during a more consi- "derable dislocation, cemented by mineral matter subsequently "introduced."* When a piece of slate is broken, it often separates into rhomboidal figures, being the effect of an imperfect crystallization which it has undergone; and when again cemented by mineral matter, something like a heave might be formed: yet still the regularity in the heaves in the tin stones, and perhaps a previously formed opinion, made me hesitate to assent to the high authority before quoted in this matter; and having observed the minor fractures in several other rocks, it appears to me probable that the same causes which produced fractures and faults on a large scale in the earth's crust, have in like manner, but on a minute scale, produced the minor fractures.

The formation of lodes, and especially sparry cross-courses, is well illustrated by the specimens marked No. 3, in which veins of pure silica cut through the fossil shells. That these veins have been formed by fractures which have afterwards been filled by deposition, will appear by inspecting the fossil shells which are split and thrown apart (see No. 3, at *a*, and the shell in the box); and in some of the veins the process of filling is not yet completed. The great

* Report, p. 316.

Crinnis lode, and the Regency copper-lodes, traverse fossiliferous rocks, and organic remains may be obtained close to their walls.

Nos. 4 and 5 show fractures of another kind—faults; and both in the altered slate and the steatite the faults are very perfect, and precisely similar to those which occur on a larger scale.

In confirmation of the heaves in the tin stones, I send a sketch of some heaves which I copied from a large rock, worn smooth by the action of the sea, on the beach forty or fifty yards north of Porthalla, in St. Keverne.

Riding down the valley, on the south-east of Luxullian, I found a large block of granite which had lately been split for building purposes, and in its centre was a piece of slate about 9 inches square, the lamination of which could be distinctly seen, but it was much altered and indurated (by heat?). The block lay at the bottom of the declivity of the hill, and about sixty or a hundred yards from the brook. I have the pleasure of sending the piece which I broke off. (No. 6.) On searching the rocks in the neighbourhood, and at the cutting near Mr Treffry's viaduct, I found several other pieces; one in particular, which had been rounded by atmospheric influence, and in appearance very like the thigh bone at the joint, projected three inches from a huge block of granite: being harder than the granite in which it was imbedded, it had better assisted decomposition, and thus showed the amount of weathering which the granite had undergone. No. 7 is a specimen of the elvan which runs along the face of the cliff near the Blackhead (the same as the Pentewan stone), in which pieces of slate are in a similar manner imbedded.

These facts appear to be confirmatory of the theory of the igneous origin of granite and elvan, and that they were thrust into the slate in a fluid state, portions of which became entangled in the igneous molten mass.

Notice of the discovery of a quantity of Pitchblende, at the Providence Mines, near St. Ives.

By Captain ISAAC PENBERTHY.

These mines are situated on the declivity of the hill which rises from St. Ives bay. The surface is wholly killas, and the mine is in killas to the depth of 50 fathoms below the adit, where the granite appears in the engine shaft, about 50 fathoms in from the cliff.

There are two lodes in these mines; viz., the south lode, from 6 inches to 2 feet wide, bearing about east and west, and underlying 10 inches in a fathom northwards; and the north or main lode, about two feet wide; both productive of yellow copper ore. These lodes have been explored in several levels, to the depth of 100 fathoms below the adit.

In the south lode the pitchblende first appeared in small quantity in the 20 fathoms level, about 7 fathoms from the intersection of the lode by a cross-course, but the principal part was found just above the 40 fathoms level, about the same distance from the cross-course.

In the main lode, the pitchblende occurred above the 30 fathoms level, under the sea, at a spot where a small vein falls in with the copper lode, but about 200 fathoms in length from the parallel spot where it occurred on the south lode.

The pitchblende occurred in small detached masses, seldom so large as the specimen on the table. The whole quantity raised has been about 3 tons. A part of it has been sold for £20 per ton. If it were all as good as the specimen £40 per ton might be obtained, but the adventurers have an idea that it is worth considerably more; I have heard as much as a shilling per pound.

I have been informed that four to five tons of this substance are annually used as a pigment for giving a very fine yellow colour

to glass and china, and that more would be used if it could be obtained. I am not acquainted with the mode of preparing it for this purpose.

It may be observed that the lodes are poorer for copper where the pitchblende occurs, and that they are not so rich in any ores close to the cross-course as at a little distance from it.

The Providence mines are wrought in almost every level under the sea. The adit is 4 fathoms deep.

The 12	fathoms	level is now	30	fathoms	in length under the sea.
20	„	„	65	„	„
30	„	„	90	„	„
40	„	„	105	„	„
50	„	„	70	„	„
60	„	„	45	„	„
70	„	„	18	„	„
80	„	„	18	„	„
90	„	„	20	„	„

The water of the mine is quite salt, and as much so in the deeper as the shallower levels, but in the deeper parts it has also an irony and bitter taste; it is warmest in the deeper levels. The quantity of water is larger in those parts of the mine which are under the sea than in the other parts. The workmen do not hear the noise of the sea in any of the levels: indeed, it is always found that where the sea breaks on a sandy beach, as it does here, the noise and the concussion are much less than when it breaks against rocks.

Contributions towards a Description of the district of Meneage.

By Mr. RICHARD THOMAS,

CORRESPONDING MEMBER OF THE SOCIETY.

This district comprehends about 58¾ square miles, of which the serpentine occupies about 26, the sienite 6¼, the greenstone and mica slate at the Lizard almost one mile, and the remaining 25½ are slate.

Masses of greenstone, some slaty and some amorphous, abound in that part of the slate formation which is near the serpentine and the sienite, and in the serpentine where it is near the slate; and masses of serpentine are found in sundry places in the slate formation; viz., north of Rosuick, and near Trezebal, Treworgey, and Polkerris. (See specimens Nos. 88, 124, 126, 145.)

The slaty formation which lies on the northern side of the serpentine and sienite, dips towards it in a direction varying between S.E. and S.W., the angle of the dip being variable from 10° to 60° or 70°, the particulars of which are given in the description of the several spots hereinafter referred to. This dip seems to have reference to the granite formation of Constantine on the north, and is a continuation of the general inclination of the slaty strata dipping throughout Cornwall (I believe without exception) from the granite.

Immediately south of Mawgan church, there appears to be a large course of elvan (see Nos. 246, 247, 248, 250) ranging about E.N.E. and W.S.W., and dipping S.S.E., which I have not had an opportunity of tracing further west, nor of examining its connexion with the cliff at Mawgan, and its extension eastward. About half-a-mile northward from this course, there appears to be another which I have only seen near Treverry. (See No. 263.)

The greenstone and mica slate forming the Lizard promontory, dip in the western cliffs E.S.E. 35° to 40°: in the southern cliffs N.E. to E.N.E. 10° to 20°: and in the eastern cliffs N. to N.E. 10° to 20°.

At Cadgwith the strata of greenstone dip N. to N.W. 15° to 30°.

At the cliff at Portreath, where there is a junction of the serpentine and the greenstone, the division is well marked, showing the serpentine overlaying the greenstone at an angle of about 45°. (See No. 26.)

I have been informed there are conglomerate formations in the cliffs near Pennare Point, but I have had no opportunity of seeing them.

On Crousa-Downs, which I believe is between 200 and 300 feet above the level of the sea, and forms a sort of plain, extending over an area of more than a mile east and west, by about a half-a-mile wide (there not being any higher ground in the neighbourhood) many pits have been sunk to the depth of 8 or 10 feet, in which are great numbers of stones of quartz and greenstone which have been more or less rounded, apparently from having been subject to attrition by the action of water: they are generally small, but some among them may be as much as six or seven pounds weight. Another such intermixture of quartz pebbles with the subsoil may be seen on a common half-a-mile north-east of Mayne-ambre in the parish of Crowan.

The serpentine rock is covered by a poor soil, owing probably to the presence of the magnesia which abounds in that stone; but where there are greenstone intersections the soil is better, in proportion to the decomposed greenstone that may exist in it. The sienite is covered by an excellent soil, and by its decomposition it yields a vast quantity of *marl*, which is used for manure, as is also much of the decomposed greenstone in and near the serpentine formation: I believe, however, that the value of these manures varies much, in proportion as the ground which affords them is more or less mixed with, or passing into, serpentine or slate.

The greenstone and micaceous slate formation at the Lizard is accompanied by a very good soil, as almost all the greenstone formations are: much of it is decomposed, and is dug up and carried off for manure.

The slaty grounds are of an ordinary character, and form in general moderately good arable lands, in some places much improved by the intersections of the masses of greenstone.

In the following list and description, the numbers refer to the several spots in the map which were examined, and to the corresponding specimens of the rocks which have been cursorily looked at and described accordingly; but it will be desirable to have a more perfect examination of them by a competent mineralogist, who may be able, among other useful deductions, to ascertain whether or not the several formations may differ in their texture as they approach to or recede from others.

Here follow references to the specimens, and descriptions of the rocks from which they were taken. The paper was accompanied by a geological map of the district.

An Account of an extraordinary Movement of the Sea in Cornwall, in July, 1843, with notices of similar movements in previous years, and also of Earthquakes which have occurred in Cornwall.

By RICHARD EDMONDS, Jun., Esq.

(Read 13th October, 1843.)

As these extraordinary movements of the sea are generally attributed to earthquakes, I will first notice the different earthquakes recorded to have been felt in this county.

The first of which I find any notice is mentioned in the "Gentleman's Magazine"* as having occurred at Falmouth in 1696, but there are no particulars of it.

The second happened on the 15th of July, 1757, and extended above 100 miles, from the Scilly Islands throughout Cornwall as far as Plymouth. A full description of it is given by Borlase in his "Natural History of Cornwall."† He also states that, about eight hours and a half before its occurrence, he observed in the fine sand east of Penzance a number of small hollow basins, from one of which there issued a strong rush of water about the size of a man's wrist, never observed there either before or since. Five days before this shock, a very destructive earthquake took place among the Azores, when several small islets rose from the sea.

The next shock on record‡ was a very slight one at Liskeard, on the 24th of February, 1759, at 10 o'clock p.m., accompanied by "blood-red rays which converged from all parts of the heavens "to one dark point, and disappeared in fifteen minutes."

In 1836, a slight disturbance of the earth was observed in the parishes of Budock and Stithians.||

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* 1750, p. 56. † p. 55. ‡ "Gentleman's Magazine," 1759, p. 143.
|| Mr. Hunt, in the 9th Report of the Cornwall Polytech. Soc.

On the 20th of October, 1837, another slight shock was felt at Camelford, Northhill, and Liskeard, as well as on the borders of Devon.*

In 1839, "a shock is said to have been felt at the Scilly Islands "on the 21st of January."†

The last shock felt in Cornwall took place on the 17th of February, 1842, between eight and nine o'clock a.m., and extended from Manaccan on the south to Cubert on the north, about 25 miles, and from Falmouth on the east to St. Hilary on the west, about 18 miles. This has been already described by Mr. Henwood‡ and Mr. Hunt,‖ but they were not then aware that it had extended so far towards the north and south. At Cubert, the noise and the tremor were similar to what would have been produced by the rapid driving of a carriage close to the house.

In the earthquakes of 1757, 1837, and 1842, the noise heard by the miners underground is variously described; viz., as the falling of the pumping machinery; the crushing together of the mining excavations; the breaking of a studdle (a wooden platform), and the deads (rubbish) being set a running; the falling of a kibble (bucket) down the shaft; the falling of a chain, &c.

The sounds on the surface were compared to thunder; the explosion of gunpowder mills; the discharge of cannon; the fall of a heavy body; the rattling of stones; the falling of a house; the rushing of waggons down an inclined railway, &c.

It is evident, either that the noises heard in the mines and on the surface were really very different, or that they were naturally referred to the accidents of most frequent occurrence in the respective situations of the observers.

The above are the only records of earthquakes in Cornwall with which I am acquainted. I now proceed to the disturbances of the sea in 1755, 1761, 1789, and 1843.

The first of these extraordinary agitations took place on the 1st of November, 1755, about 2 p.m., and four hours and a quarter after the great earthquake of Lisbon. It is fully described by Borlase,§

* Mr. Henwood, "Corn. Geo. Trans." v. p. 141. † Ibid, p. 142. ‡ Ibid, p. 459.
‖ 9th Report Corn. Polytech. Soc.
§ "Nat. Hist." p. 53. "Philos. Trans." vol. 49. p. 373.

who states that at St. Michael's Mount, the sea, when perfectly calm, about half an hour after ebb, suddenly rose and then retired; about ten minutes after it rose again nearly six feet, coming in very rapidly from the south-east: it then ebbed with the same rapidity to the westward, for about ten minutes, until it was nearly six feet lower than before: it then returned again and fell again in the same space of time. The agitation continued for about five hours and a half, and boats were hurried in and out of the pier with an impetuosity not to be resisted. At Penzance pier the sea rose and fell eight feet, coming in from the S.E. and S.S.E.: in Newlyn pier, and at Mousehole, it rose and fell ten feet, and came in from the south. By a vessel in Gwavas lake, it was ascertained, on heaving the log, that even in the decline of the commotion, the sea was running at the rate of seven miles an hour.

In addition to Dr. Borlase's account, I have been informed by two descendants of an eye-witness, that at Lamorna cove, which is on the south-western part of Mount's-bay, the sea on this occasion rushed suddenly towards the shore in vast waves, with such impetuosity, that large rounded blocks of granite from below low-water mark were swept along like pebbles, and many of them deposited far beyond high-water mark. One large block, weighing probably six or eight tons, was borne repeatedly to and fro several feet above the level of high-water, and at length deposited about ten feet above that level in the stream, where it still lies. These boulders had previously formed a barrier which prevented the fine sand from reaching the beach, except in very small quantities, but ever since their removal, it has been deposited in great abundance. This rising of the sea in waves may have been caused by the influx meeting the ebbing tide, which near Lamorna is rather strong; and this supposition agrees with Borlase's statement, that the sea was observed at Newlyn and Mousehole to come in as a wave from the south; for Newlyn, Mousehole, and Lamorna are all on the western arm of the bay, and the ebb tide sets out towards the south-west.

Similar agitations of the sea were observed on the same day, not only in different parts of Great Britain, but in other parts of Europe, in Madeira, and in the West Indies; some of which preceded the earthquake, but most of them followed it.

On the 31st of March, 1761—the day on which, at noon, happened the second great earthquake at Lisbon—another extraordinary oscillation of the sea was observed in Mount's-bay. About five o'clock, p.m., after the tide had ebbed about four hours and a half, on a sudden it advanced to the height which it would have reached an hour and a half before high-water; it then retreated again near to the point of low-water; then it advanced again, and retreated, making five advances and as many recesses in the space of an hour. At Penzance and Newlyn, the sea rose about six feet perpendicular; at St. Michael's Mount, about four feet. At Mousehole pier the sea was in great agitation, and the fishing-boats in danger. At the Scilly Islands the agitation continued more than two hours.*

On the same day an earthquake occurred at Madeira, at twenty-five minutes before noon: a slight shock was also felt in Cork about a quarter after noon.

On the 28th of July following, at 10 a.m., similar fluxes and refluxes occurred in Mount's-bay, Falmouth, Fowey, and Plymouth. The rise in this bay was at first about six feet; and when it had nearly subsided, so that the rise was only about a foot and a half, it was ascertained that the sea occupied seven minutes in flowing and seven minutes in retiring.†

I have been recently informed by three aged persons that in 1789 another such agitation occurred at the Mount and Penzance: at the former place the influx and reflux were so great and so frequent as alternately to float the vessels and leave them dry several times, and under the cliff of Penzance one of my informants saw the sea, at about half-ebb, suddenly rush in sixty or seventy yards and surround a number of mules then passing, so that they were almost compelled to swim. I could not ascertain the day or the month when this occurred.

I come now to the movement of the sea which I witnessed in Mount's-bay on the 5th of July in the present year (1843). It began about noon, when the tide had ebbed an hour and a half. I arrived at Portleven, on the north-eastern part of the bay, an hour after its commencement, and found the inhabitants in a state

* "Philos. Trans." vol. 52, p. 418. † Ibid, p. 507.

of excitement observing the sea, which, in the *interior* of the harbour, was moving up and down in a most unaccountable manner, whilst at the mouth it was as smooth as usual. The *inner* basin of the harbour is about 150 yards long, lying N. and S.; the *outer* part is double that length, and lies W.S.W., opening like the mouth of a bell. The agitation extended about 300 yards from the northern shore of the harbour, but not the least disturbance could be seen in the outer part for a hundred yards within the pier-head. I remained at Portleven above an hour, but, having other engagements, could only watch the movement at intervals. From what I saw, and from what I afterwards heard from the fishermen, it appears that the sea rushed inwards from the middle of the outer harbour along the western arm, rising about four feet, and retired by the eastern arm, occupying between ten and fiften minutes in the circuit. After a pause of eight or ten minutes, it rushed in and out again in the same manner, and so continued, but with gradually decreasing violence, until low-water. A fisherman came into the harbour in his boat an hour after the commencement of the agitation, and from the calmness of the sea at the pier-head, had no suspicion that there was any run within the pier, until some persons on shore called to him that it was dangerous to land, and presently, as he entered the inner basin, one of the influxes carried his boat along with great impetuosity for a hundred yards towards the northern shore, and retiring, left it dry on the beach.

At Penzance, on the northern and inmost part of the bay, the agitation was not only in the pier, which opens towards the north-east, but likewise behind it for more than a quarter of a mile towards the south and south-west. The eminence on which Penzance stands terminates in a ledge of rocks called the "Battery Rocks," which are dry at low-water. Between these and another rock (60 yards on the east) called "Carn Olver" there is a channel (also dry at low-water), through which two most unusual currents were passing, nearly parallel with each other, and eddying and foaming in a remarkable manner: they reached from the elbow in the back of the pier to beyond the point of the "Battery Rocks," a distance of 400 yards towards the south-west. The eastern current was flowing continually seaward close to "Carn Olver," the

western one moved alternately in and out by the "Battery Rocks." The latter was observed at noon to flow inward from the "Battery Point," and immediately to retire in the same line; this was repeated several times, the influx lasting about ten minutes, and the reflux only half that time. Two young men were then bathing near the "Point;" one of them, who had gone into the water on the western side of the rocks, was, on reaching the "Point," carried inward along the eastern side with such rapidity that, although a good swimmer, he was unable to stem the current, and was for some time afraid that he should never regain the shore; the other, seeing that the current was only ten or twelve yards in breadth, went into it from the eastern side of the rocks, swam across it, and continued to swim on the outside of it around the "Point," until he landed on the western side; he thus ascertained that there was no sensible disturbance beyond twelve or fifteen yards south of the "Battery Point." He also dived to the bottom where the current was from eight to ten feet deep, and found it as strong there as on the surface: he considered its velocity when greatest to be between three and four miles an hour. The agitation continued to increase from noon until half-past twelve; and at one its violence was not at all diminished. In the meantime, within the pier, the sea was observed first to retire suddenly to a considerable distance, and soon afterwards to return, occupying in both movements nearly twenty minutes, and so it continued for two or three hours; whilst at the pier-head there was a most remarkable eddy, which whirled the boats in all directions.

At Newlyn, in the north-west corner of the bay, the sea first fell suddenly about four feet, rushing with a great eddy towards the south, to the distance of half a mile, in a current of about a quarter of a mile in breadth, and then returned in the same state of agitation to its former level. This ebbing and flowing was observed four times successively within about an hour and a half. The large fishing-boats riding at their moorings with their bows toward the wind (then about south) were, during the outward currents, turned towards the north. My informant, a very intelligent fisherman, who went in a boat on the water whilst it was thus oscillating, estimated the average rate of the current at three miles an hour.

At Marazion, three miles east of Penzance, one of the influxes was noticed about one o'clock, when the sea rushed in from the south about fifty yards, to the height of four or five feet, and then retired to its former level, occupying about ten minutes in each movement. Between two and three o'clock, the causeway from Marazion to the Mount was dry, and after more than half-an-hour the central part of it was again covered.

Between Marazion and Penzance, where the water is very shallow, no agitation was remarked.

At Mousehole, on the western arm of the bay, two miles S.W. of Newlyn, there was so great an agitation that one of the large fishing-boats parted its hawser, and was carried out of the pier; but no rise nor fall of the water was noticed.

Mousehole on the west, and Portleven on the east, distant from each other ten miles across the bay, were the limits of the observed disturbance. The tide in this bay rises about twenty feet at the highest springs, during which at low-water all the piers are dry.

During this agitation the sky was overcast with thunder-clouds towards the south-east, and early in the morning a distant thunder-storm had been heard in that direction. In the afternoon, before the agitation had entirely subsided, a storm of wind came on from the south, and almost simultaneously a heavy sea, in which the fishing-boats out at the time had a narrow escape; and the sudden cessation of the wind and sea was as remarkable as their sudden rise.

The weather on the 5th, and throughout the week, was fine, with the exception of an occasional shower, the wind being generally about west; the temperature ranged in the daytime during the week from 56° to 64°. The barometer, at 9 a.m. on the 3rd, was 29.80; on the 4th, 29.77; on the 5th, 29.52 (its minimum this day was 29.50); on the 6th, 29.65; on the 7th, 29.70; and on the 8th, 29.75.

It is remarkable that in the recent disturbance in this bay the agitation of the sea was apparently confined to a short distance from the shore, and at Portleven did not extend even to the pier-head. With a view to account for this, let us suppose that an upward shock takes place at the bottom of the sea, a few leagues from our coast, and that a shoal with one of its sides perpendicular to our

shore is thereby made to vibrate. The shock thus communicated to the water will be transmitted with a velocity much greater than that with which sound travels through air, and may cause the water along the shore to rush up the beach in the same manner as a smart blow at one end of a line of marbles causes the marble at the opposite end to fly off, whilst all the others remain stationary. When this body of water falls back to the stationary or less disturbed part of the sea, it will by the reaction be driven a second time up the beach, and thus the fluxes and refluxes, like the motion of a pendulum, may continue for a long time, although originated by a single shock.

Agitations beginning with an *influx* may be thus accounted for; but they generally commence with an *efflux*, which may be produced by the inclined plane descending from the coast being made to vibrate by a shock upwards; the effect of which would be to drive a considerable body of water seaward.

The irregularity which often attends these oscillations may arise from a subsequent shock interfering with the effects of a preceding one, or from the inequalities of the submarine ground, or from the influence of strong tides.

The concussion of vessels by a submarine shock is oftentimes very great; yet no wave is seen because the motion is too rapid for the formation of a wave, and the surface of the water is (like a rock dashed in pieces by a violent blow) broken into drops, as was seen in Calabria immediately before the earthquake of 1638, when the sea appeared "like a lake in a violent shower of rain covered over "with little bubbles."

The local storms of wind, rain, or lightning, which so often follow earthquakes, may proceed from the disturbance of the earth's electrical equilibrium, produced by its vibration; and in submarine earthquakes they may also, in some measure, be owing to the violent shock communicated to the atmosphere by the sudden jerking up of a large portion of the surface of the sea, which cannot but occasion a considerable aërial disturbance, both mechanical and electrical.

If we now raise our thoughts from the *philosophy*, or *secondary causes*, of earthquakes, to their *Great First Cause*, we must ascribe

it to His mercy, that whilst whole cities and multitudes of the human race have been destroyed by them during the last century, we have only slightly felt them, and have been preserved from their fatal consequences.

About a fortnight after the meeting of the Society, another of these extraordinary movements of the sea occurred in Mount's-bay and Plymouth.

It was observed at Penzance on the evening of the 30th of Oct. (1843), the tide being nearly two hours flood, the sea smooth, and the wind blowing strong from the north-east, with rain. Three persons, who had watched the movement from the pier-head for three-quarters of an hour, informed me that about 5 o'clock the sea suddenly rushed into the harbour, coming round the pier-head from the south-west, and causing a rise in the water of about five feet; it then rushed back in the same line. This occurred three times successively in about forty minutes. A small vessel which lay aground in the pier was suddenly floated and carried out several yards, directly against the wind, and immediately borne in again by the succeeding influx; after which, having been secured by a hawser, she was left aground on her side, and then again floated, twice within half-an-hour.

On the same evening a similar flux and reflux occurred at Plymouth, the velocity of which was estimated by the master of a vessel then lying there, at eight knots an hour.

The thermometer and barometer were respectively, on the—

	Nine o'clock.	Three o'clock.	Nine o'clock.	Wind.
27th of October	49° / 29·50	50° / 29·30	52° / 28·95	S.W. strong gale.
28th „	47° / 29·15	51° / 29·25	45° / 29·30	W.N.W.
29th „	46° / 29·35	52° / 29·35	46° / 29·35	Variable.
30th „	46° / 29·20	51° / 29·10	49° / 29·00	N.E.
31st „	47° / 29·30	52° / 29·30	47° / 29·45	N.E.
1st of November	46° / 29·50	55° / 29·50	49° / 29 54	Variable.
2nd „	49° / 29 63	54° / 29·65	51° / 29·65	Variable.

The minimum observation, therefore, of the barometer (from the 28th of October to the 1st of November) was coincident with the agitation, as was the case also in July last; and while the disturbance in July was accompanied by thunder-clouds, this of October was attended with rain.

This second agitation in 1843 occurred about four months after the first, which is almost exactly the interval between the two agitations in Ilfracombe,* succeeding the great earthquake of 1755, and also between those in Mount's-bay which succeeded the great earthquake of 1761; for in 1843 the interval was *one hundred and seventeen days;* in 1755, *one hundred and eighteen days;* and in 1761, *one hundred and nineteen days.*

My brother, T. R. Edmonds (Actuary of the Legal and General Assurance Society), on reading the preceding paragraph, remarked that 118 days are almost exactly four lunations: and finding that the interval between the earthquake at Guadaloupe, on the 8th of February, and the agitation here on the 5th of July last, was 147 days, or within about half-a-day of five lunations: and also finding that the interval between the two earthquakes in Cornwall, nearest to one another in point of time (viz., those of 15th of July, 1757, and 24th of February, 1759), was 589 days, or within a day of five times four lunations, he was led to continue his inquiry in reference to *all* the shocks of the earth and submarine shocks in Cornwall whose dates are known, as well as the two at Ilfracombe and Guadaloupe, when he ascertained that the interval between any two of the six shocks before that of 1837, or of the five shocks since, has been almost exactly some multiple of a lunation, as will appear from the following tables.

In these tables the dates marked with asterisks are those of agitations of the sea where no shocks were felt; those of the 1st of November, 1755, and the 31st of March, 1761, refer to the agitations of the sea occasioned by the great earthquakes of Lisbon; the remaining dates are those of simple shocks of the earth unaccompanied with such agitations.

* 1st Nov., 1755, and 27th Feb., 1756.

TABLE I.

(1755—1761, 71 lunations.)

Dates.	Intervals.	
	Days.	Lunations.
1755, November 1st		
1756, February 27th *	118	4·00
1757, July 15th	504	17·07
1759, February 24th	589	19 94
1761, March 31st	766	25·94
1761, July 28th *	119	4·03
Total	2096	70·98

TABLE II.

(1839—1843, 59 lunations.)

Dates.	Intervals.	
	Days.	Lunations.
1839, January 21st		
1842, February 17th	1123	38·03
1843, February 8th	356	12·06
1843, July 5th *	147	4·98
1843, October 30th *	117	3·96
Total	1743	59·03

It may be considered worthy of remark, that at each of the five recent shocks the moon was at or near her first quarter.

As I have in the preceding paper, on several occasions, alluded to the state of the tide, I will here mention that the average time of high-water in Mount's-bay, at new and full moon, is about half-an-hour after four o'clock, or about four hours and a half after the moon's southing; and that the interval between two successive times of high-water is about twelve hours and twenty-four minutes.

On the Killas group of Cornwall and South Devon; its relations to the subordinate formations in Central and North Devon and West Somerset; its natural subdivisions; and its true position in the scale of British strata.

By the Rev. DAVID WILLIAMS,

CORRESPONDING MEMBER OF THE SOCIETY.

I now exhibit to the Society maps, coloured geologically, from Bridgewater in Somersetshire to the Land's End in Cornwall, with a section from the Foreland on the Bristol Channel to Lantioc Bay, east of Fowey on the English Channel, to show the superposition of the Cornish killas with regard to all the subordinate formations with which it is inseparably associated, and the four natural subdivisions into which it resolves itself by characteristic mineral and organic types, which are persistent throughout their entire range. This great and important classification has forced itself upon me by the constant repetition of the same successions in every traverse I have made of the killas country from sea to sea.

The innumerable minute details of strike and dip which I have registered from north to south and from east to west, fully convince me that the Cornish killas in the ascending order crowns a magnificent consecutive series such as I have illustrated on the map and section; a series however (complete and perfect as it is in all its particulars) which manifestly constitutes only a part of some vast system as yet unfolded.

I formerly subdivided the entire group into ten component members, the nethermost of which was the Cannington Park limestone, near Bridgewater; but many circumstances have since induced me to suspect, that though geographically it was associated with the Quantocks, it geologically appertained to the Mendips, and troughed

away towards them, as Mr. Conybeare has long ago suggested.* In this view the foreland or Dunkerry sandstones (No. 2) will provisionally constitute the mineralogical base of the entire system: these are almost identical in mineral composition with the old red sandstone of Monmouthshire and the Mendips, close by, and are, I believe, a more southward prolongation of it. I deny more confidently than ever, that there exists any axis or anticlinal line of fracture in the whole of Exmoor: every geological fact, and all the associated physical evidences, negative such a supposition. The true mechanism of the structure of Exmoor and the Quantocks is, as I announced at Liverpool in 1837, that these red sandstones and shales (hitherto containing only plants), with white quartz, conglomerates, and green compact calcareous grits, emerge from beneath the Linton slates and the other overlying masses, and culminate in three parallel mountain folds with their corresponding inverted flexures or valleys, but are finally lost on the north-east of the Quantocks, where their exposed summits, barely showing through the ridges of the new red sandstone in long, low undulations, indicate them to be rolling away towards the Mendips, the mineral axis of which is old red sandstone, as has been shown long since by Dr. Buckland and Mr. Conybeare.† This view of the true position of the Devonian system; viz., that it occupies an enormous interval between the old red sandstone and the mountain limestone, was first suggested to me about two years ago, on observing in the neighbourhood of Bristol a hard junction between those two formations: subsequently I have been much gratified on finding that Mr. Hopkins and Mr. Daniel Sharpe have, by independent observations at different localities in the north of England, remarked an unconformity also of strike and dip between them. Mr. Hopkins observes, "After the elevation of "the older rocks, including the old red sandstone, the whole district

* "Geology of England and Wales:" Section from the Land's End to the German Ocean.

† It is proper to observe that a thick band of dark blue and oftentimes coarse dull arenaceous limestone is included in these red sandstones in Croyd Hill, near Minehead, and along the east and north-east flank of the Quantocks, very essentially differing from the cornstones or any calcareous beds hitherto described as pertaining to the old red: it commonly contains in its shales and planes of deposition carbonaceous matter oftentimes like powdery coal smut, and as often in extremely thin films with a high metallic lustre: it also contains corals in great abundance, which Mr. Lonsdale recognized as the same species as some others he had described from the lower Palæozoic rocks of South Wales.

"must have been under the sea, and subjected to the powerful "action of denuding causes, by which the up-turned edges of the "disturbed beds were worn to an even surface, and the existing "masses of old red conglomerate washed into the hollows: the "mountain limestone was deposited on the worn and even surface "of these older rocks."* Mr. Hopkins states previously, "The "mountain limestone reposes unconformably on the older forma-"tions, which, within the limestone band, occupy the surface."† At the close of a communication to the "London and Edinburgh Philosophical Journal" for June, 1842, published on the same day Mr. Hopkins' "Memoir" was read at the Geological Society, I indirectly adverted to the views I entertained of the position of the Devon and Cornwall beds; and in an announcement of them at the meeting of the British Association, held at Manchester in the same month, I was constrained to invoke an elevation and submergence of the old red sandstone prior to the deposition of the mountain limestone, to as great and perhaps greater extent than was contended for by Mr. Hopkins.‡ Mr. Sharpe has also observed an unconformity of strike and dip between the old red sandstone and mountain limestone above Kirkby Lonsdale, the angle of dip varying five degrees, and the strike fifty; "farther westward," he observes, "the "want of conformity is still more manifest," the variation in strike amounting to seventy degrees, and lower down the valley of the Lune other instances still more remarkable are adverted to. Mr. Sharpe concludes, "There is abundant evidence of both the old red "sandstone and Ludlow rocks having been dislocated before the "accumulation of the mountain limestone, as the limestone of Ken-"dale Fell rests in a nearly horizontal position upon the up-raised "edges of an anticlinal ridge of Ludlow rock, from which a cover-"ing of old red sandstone has been partially denudated."‖ Now, if a break or interruption in the succession actually exists between them, as is indicated by such hard junction in the west of England, and unconformity in the north, the interval implied might of course be sufficiently capacious for the reception of all the Devonian and Cornish rocks, and others which may be elsewhere still above them.

* "Geological Proceedings," No. 90, p. 760. † Ibid, p. 757. ‡ "Transactions of the Sections," p. 61. ‖ "Geological Proceedings," No. 85, pp. 605, 607.

These red sandstones (No. 2) are succeeded in an ascending and critically consecutive order by eight other great series of deposits, which severally vary in their mineral types and organic contents, the last or uppermost of which is the Cornish killas. That this great group overlies the floriferous or plant-bearing series, as I have termed them, or the "carbonaceous rocks," as they have been designated by Sir H. De la Beche and Professor Phillips, is as capable of demonstration as any geological fact of superposition on record. The diagrams which I now exhibit I have carefully copied from natural sections (almost as simple as those of tabular superposition), which show the killas to rest, as if tranquilly piled, on the plant or carbonaceous beds at Boscastle, Petherwin, Tavistock, &c. &c., and these are confirmed by the same continuous carbonaceous rocks in their most prominent and characteristic mineral and organic types, closely investing nearly the whole of Dartmoor, and underlying the entire killas country on the east, south, and west of it.

These facts confirm more strongly, if possible, the opinion I have long since expressed,* and I cannot but think they should either be disproved, or their legitimate consequences admitted.

The killas group naturally resolves itself into four subdivisions, which are severally characterized by appropriate mineral types and varying percentages of organic genera and species: these different members are inseparably linked together on their confines, by a common alternation of beds, and by insensible mineral gradations, and in the great natural scale are arranged in the following descending order:—

No. 4. The Ichthypherous, or Fish-bearing killas.

No. 3. The Metalliferous killas.

No. 2. The Padstow, or Tamar killas.

No. 1. The Tintagel, or Clymenien killas.

There is nothing arbitrary or inconstant in this fourfold division of the killas group, though from the several granitic interferences, and other derangements, they oftentimes deviate considerably in their

* See "Plausible Reasons and Positive Proofs; showing that no portion of the Devonian system can be of the age of the old red sandstone." By the Author. "London and Edin. Phil. Mag." Feb., 1842.

strike, and present a greater or less amount of surface according to the angle of inclination which their beds exhibit, or according as they may be repeated or not by flexures, and the varying bulk of matter which enters into their composition at different localities. With these limitations, and the circumstance that Nos. 1 and 4 are vast spheroid masses, the former thinning away to nothing up the Fowey estuary, near Lostwithiel, and the latter not being continued to either the south or the east of Dartmoor, every traverse made at right angles to the direction of their strike or bearing gives the same succession of the same peculiar mineral deposits, and the same sections throughout the entire killas region, from Torbay on the east to the Bristol Channel on the west.

No. 4, though containing interpolations of red and grey grits and impure calcareous beds, is usually abundantly variegated as a whole, its strata being red, green, greenish-grey, purple, and mottled purple and green, commonly glossy and unctuous, and of a more exquisitely delicate texture and foliated structure than any I have ever met with. It is characterized by the abundant remains of fish, which were first discovered by the Messrs. Couch, of Polperro, as has been fairly admitted, and some of which have been exhibited to the Society by Mr. Peach. They pre-eminently characterize this upper department of the killas, sometimes to such an amount that I entertain no doubt that a fish-bone bed as replete with their remains as that at Watchet, and Aust cliff in the Lias of the Severn, will hereafter be discovered; I have myself, in fact, found a fragment of such Ichthyolite bed in a portion of cliff which had fallen down on the shore, but have not yet detected it *in situ;* it is a consolidated congeries of fish remains. Of the great number of specimens I have collected, or which have been kindly shown me by Mr. Peach and Mr. Couch, with the exception of some defensive fins and fin rays which might or might not be "Onchus," they all appear to me to differ even in genera from any which have hitherto been figured from the Ludlow rocks or the old red sandstone.

This member of the killas series is of considerable thickness to the eastward, but gradually decreases in dimensions as it advances to the westward; on the eastern coast it extends from Man Sands,

near Brixham, by Noss Point on the Dart, and East Allington and Aveton Gifford, to the Start and Prawle Points, and the Bolt Head and Tail; where, though oftentimes in such conditions as refer to partial reduction by active heat, and even to semifusion, it may be followed and identified. Along its northern line from Man Sands to near the mouths of the Erme and Yealm rivers, in Bigbury Bay, it contains repeated interpolations of the red and grey grits and red slates of the next subordinate killas series (No. 3), and everywhere rests conformably upon it, with an almost permanent southern dip as far as the parallel of Stokenham and Kingsbridge, along which its beds are thrown back into a fan-shaped arrangement and a high northern dip. From Slapton Sands therefore on the east, to Thurlestone, in Bigbury Bay, on the west, they present a synclinal axis; from thence round Bigbury Bay to Yealm mouth, and thence in a line drawn to Cawsand on the west of Plymouth Sound, it overlies No. 3 killas with a high southern dip; round Whitsand Bay it constitutes the far greater portion of the cliffs in a narrow belt, sometimes thinning out in its deeper recesses, and unmasking the metalliferous killas, which is seen incontrovertibly to pass into and underlie it: this is notably the case in the deeper inlet of Looe Bay, where, from Millendreth to near Hannafore Point, there is not a vestige of it; Looe Island, however, consists entirely of it, where its beds on the north side dip S. 40°, and thence increase their inclination to vertical, and apparently 80° to 85° N. on the south end, in a fine fan-shaped form.

The eastern cliffs, from West Looe to Hannafore Point, where the fish-bearing killas again set on, afford fine unbroken sections north and south, showing the gradual transition of No. 3 into No. 4, and the indisputable underlie of the former. From Hannafore Point to near Hendrasick, No. 4 dips steadily and uniformly to the south and S.S.E., at high but varying angles: at Hendrasick cove, a great up-cast fault has brought No. 3 killas into hard collision with the middle beds of No. 4, which, after a variety of strange contortions, plunge headlong downwards after the junction line; but southward of this, on to Oarstone, and westward, to Talland, Polperro, Lantioc Bay, and the Fowey Ferry at Bodinick, they settle down to a high north and north-eastern dip. From Lantioc

Bay their southern line or terms, quitting the coast, strike off by Lanteglos and the Fowey ferry to "ancient inscribed stone" on the Ordnance map, on the north-west of Fowey, where they curve round and follow nearly the north and south line of road to Lostwithiel for two miles and a half, from whence they trend off obliquely to the north-east to Latine, on the west bank of the river, opposite St. Winnow, where, meeting with their northern line, they taper out to nothing; from Lantioc Bay, after their south, and round their west line just described, they are manifestly included in a trough of the subordinate fossiliferous killas (No. 3), which supports them everywhere along its northern and north-eastern confines, and is distinctly seen to emerge from below them at Lantioc Bay; at a little south of Bodinick, and north of Fowey; and all round their curved line up to Lantine. From Pencarrow Point and the Greber Head, round by Par Sands and St. Blazey, to the granite at Lanlivery, a powerful abnormal force has wrenched the beds out of their mean direction into a huge elbow with a flexured outline, from the inner angle of which No. 4 killas is deflected with them into a nearly north and south strike after the Fowey river and its eastward and westward banks.

With the exception of fish, other organic remains appear to be very rare. Mr. Couch, jun., however, has discovered several specimens of a small or young *bellerophon* at Polperro; and I have collected *spirifers*, &c., up the Dart, and *corals* and *crinoidea* in it at Whitsand Bay, and Beeson and Hall Sands, near the Start.

An abandoned mine near Lansallos, apparently one of the many monuments in Cornwall of the speculative epidemic of 1835, is the only instance I remember of any workings for metals, either ancient or modern, throughout its entire range. It affords good bluish-grey roofing-slates near Dartmouth, and would yield them also at other localities, probably, if sought for; but I know of no other quarries.

I have gone into details in regard to this series more precisely and particularly than I propose to give of the others, because its true position, and its relations to them, have hitherto been altogether mistaken: that it does not underlie the great killas mass, or in any way constitute "a south Devon axis," must be obvious from these

structural details, and the fact that it is of posterior formation to the floriferous and carbonaceous rocks. The distance in miles, in fact, along which it gives steady southward dips compared to that at which its beds are reversed and present northern dips, to say nothing of the permanent underlie of the abundantly fossiliferous and metalliferous killas (No. 3), the next in descending order, is thirty-four of the former and eighteen of the latter.

No. 3, or the metalliferous killas, is in almost diametrical mineral and organic contrast to the former series; so much so that anything like glossy, delicate, and crystalline slate, and fish remains, are as rare exceptions in it as metalliferous lodes and red and grey sandstones, and coarse arenaceous schists with innumerable organic remains of many genera and species, are in the other. The abundant evidences of its underlying the fish-bearing killas (No. 4) have been referred to in the description of that series.

No. 3 may be described as a vast detrital deposit of red and grey grits, containing throughout greater or less admixtures of volcanic ash or mud, in the form of blue or grey schists, red slates, &c. From this circumstance, and the enormity of its mass, it constitutes a broad and well-defined line of demarcation, and an invaluable middle term in a classification or analysis of the Cornish killas. At present I can only express myself generally, by observing that whether coarse or arenaceous schist obtains in some localities, or red and grey grits, either passing into quartz rocks or thickly intersected by quartz veins, predominate in others, a sufficient proportion of the lesser ingredients is uniformly present, or close at hand, to determine their inseparable relations.

It contains nearly all the lodes of tin and copper (including those of the granites which have been generated by its reduction in the volcanic furnaces) of any value in the killas group, except the inferior mines about Tavistock,* and on either side of Hingston Down, between Tavistock and Callington. One of its lodes, at Carn Brea, has probably yielded as much ore as all those Tavistock and Callington mines together.

* The rich and admirably-conducted mine Wheal Friendship is in the floriferous or carbonaceous series below the killas.

All the coral limestones of Torbay, from Babbicombe to Berry Head, are included in its upper terms there, which is sufficiently shown by its lower arenaceous schists and grits, such as overlie the Plymouth limestones of Mount Batten and Plymstock, being protruded through the Torquay* and Brixham limestones; viz., at Meadfoot Sands in the former case, and Mudstone Sands in the latter; and by those limestones containing thick interpolations of the same red slates (*e.g.* Daddy-hole Cove, near Torquay, &c. &c.) which pass from No. 3 killas into No. 4 above, and by the limestones at Sharkham Point, south of Brixham, with their upper red grits and schists, being closely associated with, and immediately underlying, the delicate upper killas (No. 4) at Man Sands.

The Dart sections describe precisely the same history of events, but in simpler and more explicit terms. From near Totnes to Sandridge Point, a nearly four-mile succession of red and grey sandstones, red slates, and calcareo-arenaceous grey schists (the whole at intervals showing efforts of the tiny coral creatures to establish their settlements), clearly underlie the limestones of Watton and Galmpton; and these in their turn, along the south shore of the Galmpton Creek to Greenaway House and Quay Ferry, as clearly underlie the upper red and grey grits and coarse schists, which continue for almost a mile to near Noss Point, and there support the upper killas (No. 4), which from thence to the mouth of the Dart, and the little bay west of it on the south of Stoke Fleming, overlie them with a permanent high southern dip.

The sections afforded by the Torbay coast on one side, and by the Dart and the intermediate country on the other, also clearly show that the Torquay and Yalberton limestones (part of the outer zone of a great curve) are conveyed to Churston Ferrers and Brixham by flexure and undulation. These limestones become of very attenuated dimensions at Ditsham, Cornworthy, and Harberton Ford, west of the Dart, and are represented farther westward by a broad calcareous, and often abundantly fossiliferous, band of grits and arenaceous schist, apparent at Staddon Point, and north of it in Plymouth

* This remarkable fracture was first noticed, many years since, by Sir Henry De la Beche. See "Geological Transactions."

Sound, at Hessenford, at East and West Looe, Fowey, Gorran, Carhayes, Veryan, and Gerrans Bay, and probably at Watergate Bay on the north coast.

This member of the killas group, considerable as it is there, is of insignificant dimensions on the east, compared to its vast development on the west, where it is evidently augmented by the introduction of new terms, derived apparently from local volcanic vomitories, the mud, ash, and elvan dykes, whose contents even now, in numerous instances, show striking affinities with the adjacent schists. The relative scarcity of ash, mud, and porphyry dykes on the east, is attended by a corresponding absence of much of the great schistose masses on the west, and by a greater preponderance of red and grey grits; whereas the gradually-increasing frequency westward of the ash, schist, and porphyry dykes, such as are seen from Redding Point (west of Plymouth Sound) to Cawsand, and abundantly elsewhere, is accompanied by augmenting interpolations of schistose matter (commonly however of an arenaceous character), and by less frequent beds of sandstone, although the red and grey grits of St. Agnes Beacon, or the eastward cliffs of the Helford creek under Mawnan, would suffer little in comparison with their cognate and congenerous deposits at Cockington and Windmill Hill, near Torquay. Nos. 3 and 4 killas, in fact, at either extremity, may be said to be adjusted together like a solid parallelogram cut into two wedges, the thin edge of the one being fitted against the broad head of the other.

This series to the eastward forms a portion of the outer zone of a great triple series of parallel concentric curves, the inner one of which, composed entirely of the floral or carbonaceous rocks, conforms perfectly to the south-east outline of the granite of Dartmoor, and in consequence (taking about its middle terms) it ranges from Cockington, near Torquay, by Cornworthy on the Dart, to Morleigh, Black-Down, the south of Modbury, Holbeton and Staddon and Redding Points, on either side of Plymouth Sound; west of the latter, and near the huge dyke of porphyry at Cawsand, a succession of dips from S. to S.S.W., S.W., and finally W., mark the angle from which its strike deviates to St. Anthony, Sheviock, Hessenford, Bin-Down, St. Keyne, and from thence follow the lofty

ridges of heather-brown hills by Pinnock Common, Five-Barrow Hill, Bodmin Downs, St. Breocks and Denzel Downs, to Watergate Bay: from this nearly central line, its beds on the west roll out to the southward in endless repetitions, by long undulations or rapid flexures as far as the granite of St. Ives on the north channel, and over the whole peninsula to the sea on the south, from Pencarrow point east of Fowey, to Falmouth, the Lizard serpentine and hornblende rocks, and the granite of Penzance.

Mr. Peach informs me, that with the liberal loan of books by the President, Sir Charles Lemon, he has been able to identify the following orthides which he has discovered in the vicinity of Gorran; viz., *Orthis lata, orbicularis, alternata, canalis, flabellulum, testudinaria, interlineata, sordida, plicata.* Five of the above species have also been found in the lower beds of the palæozoic rocks of Wales, one from the higher beds, and the remaining three, according to the lists of Professor Phillips and Mr. Sowerby, appear as yet to be peculiar to Devon and Cornwall: I feel assured that my collection will add some new and remarkable species to the above when described (as I hope they shortly will be) by that excellent naturalist Mr. James Sowerby.

The remains of fish, which occur so plentifully in the upper series, are apparently as rare in this as fossil molluscs, &c. are in the other. Sir H. De la Beche has however found a specimen at St. Columb Porth, and Mr. Phillips another at Meadfoot Sands, near Torquay, both in this formation.*

No. 2 killas is distinguished from the former by being an entirely independent series throughout, except on its upper and lower confines, along which it passes by alternation and mineral gradation into Nos. 3 and 1. Its mean bounding line from No. 3 is just above the range of the Plymouth limestones, or their equivalent grey, calcareous, and fossiliferous slates which supply their intervals of continuity; these are immediately succeeded below by an enormously thick suite of slates, strongly characterized as green, blue,

* See Phillips's "Palæozoic Fossils of Cornwall, Devon," &c. I have found portions of fish bones as low down as the Linton slates, and coprolitic-looking bodies in the trilobite slates near Barnstaple; and Mr. Parker, jun., late of Exeter, found a beautiful tooth in the Posidonia limestones of the Coddon Hill grist series at Doddiscomb Leigh, north of Chudleigh, which Prof. Owen pronounced to belong to a genus of fishes hitherto found only in the Urals.

purple, and grey (the purple chiefly prevailing), in almost endless alternation, down to the upper beds of No. 1. Abundant facilities of identifying and observing their striking peculiarities, as contrasted with all or either of the others, are afforded, more especially by the cliffs on either side the Tamar, from Plymouth up to near Pentilly Castle on the eastward region, and the shores of the Padstow estuary on the west, from Wadebridge to Stepper and Pentire points at its mouth. The sections and succession of the same mineral beds, with the same fossils in the upper ones, and the same apparent absence of them in the lower, are so complete along the Padstow shores, that, regarding the same variegated beds underlying the same grey calcareous slates, and these in their turn in like manner underlying the arenaceous and coarse schistose deposits of No. 3 on the south; all the facts and circumstances were too strikingly associated in the same order to permit me to entertain much doubt of their identity, even at an early period of my survey, before I had proved their continuity throughout the intermediate region, and collected along the north shore of the Padstow river a greater abundance of the same *trilobites*, *molluscs*, *corals*, and *crinoidea*, than I had gathered among the same grey calcareous slates in the same relative position near Plymouth.

Another marked and peculiar feature of this series, compared to Nos. 3 and 4, is the total absence of the red and grey detrital aggregates, or their coarse arenaceous admixture, such as obtained throughout No. 3; while among all its vast terms below the level of the Plymouth limestones and their representative grey calcareous slates, east and west, I have hitherto been as unsuccessful as Prof. Phillips and Mr. Wm. Saunders in discovering any organic remains.

The limestones of Rock Ferry, opposite Padstow; of Butterville and Millaton, near St. Germans; of Plymouth, Yealmpton, Ugborough, Dartington, Berry-Pomeroy, Marldon, Broadhempston, Ipplepen, Denbury, Abbot's and King's Kerswell, Newton Bushel, and the east and west Agwells, belong to the upper terms of this series. Judging from their position and apparent underlie, and the intimate association and intermixture of the purple and variegated slates, the Ipplepen, Denbury, Agwells, and Newton Bushel limestones occupy a somewhat lower level than those of

Little Hempston, Bunker's-hill (near Totnes), Berry-Pomeroy, and Abbot's and King's Kerswell, the latter being parted by, and associated with, the upper grey calcareous and fossiliferous slates which so commonly constitute the true equivalents of the Plymouth limestones in their absence. My arrangement, in fact, of the South Devon limestones has been governed entirely by the order and succession of the killas and carbonaceous series which there severally envelope them, and there is no other rule, with security from error, which can be relied upon. The slates and grits are constants; the limestones, accidents. In this view the lime-rocks of Buckfastleigh, Ashburton, Bickington, Chudleigh, Ideford, and Lyndridge, belong to the floriferous or carbonaceous series, at about the same level as the Bampton, Holcomb, Rogus, and Westleigh limestones on the north, all of them perhaps not much below the horizontal parallel of the Petherwin. Some of the Chudleigh fossils, so far as their evidence is of any value, are apparently identical with some of the Petherwin.

It appears throughout to be as poor in metals as No. 4, as I do not remember any lode of any promise or importance being worked in it; it however affords roofing-slates, which I believe would equal in quality any in England, if quarried to a sufficient depth, and with the requisite skill and capital.

Its northern line or boundary ranges from Staple-hill, on the south-west of Bovey-heath, near Chudleigh, by the north of Ingsdon, to a little south of Bickington and Ashburton; a little east of Buckfastleigh; the south of Dean Church; South Brent, and Ivybridge, to Beechwood and Shaughwood, up to which point it is in hard junction with the carbonaceous rocks; from thence it takes a westward strike (accompanied by the Tintagel killas (No. 1) which there first sets on) to Tamerton Foliot; the north of Landulph; Pillaton, and the north of Quethiock, to the south foot of Caradon Down; from hence the entire series is represented chiefly by a narrow band of the upper beds which flank the granite, by St. Neots to Cardinham, on the west of which it again expands; and its northern line ranges after the west escarpment of the granite to Blisland and the west of St. Breward, where, meeting again with the lower killas series, No. 1 (which had described a great semicircle from St. Ive

round the same Bodmin Moor granite by its eastern, northern, and north-western frontiers), they range together in a nearly east and west direction by a little north of Endellion, to the sea, between Portquin and Porteath: strange as these remarkable lines may appear to some, I am convinced they will be obvious to any one who will follow them out as I have done.

Its southern terms are clearly deflected to the north-west, on the west side of the Tamar, conformably to the deviation in strike of No. 3, at Cawsand, as before adverted to; advancing in this direction towards Menheniot and Quethiock, the beds are seen to be no longer affected by the high angle of dip which had displayed the entire series in such minute detail and fine succession on the Tamar (as it also does from Endellion to Constantine Bay on the west of Padstow); but they have settled down to so low an inclination as has permitted the metalliferous series (No. 3) to be expanded over a great portion of the intermediate area, from a mile or two north-west of St. Germans to nearly three miles north of Liskeard.

A similar phenomenon may be observed on the north-west of Bodmin, over a considerable area, where the upper grey calcareous beds of No 2, being sometimes apparently flat, or at others inclining at a very low dip, conceal all the subordinate variegated beds, until between St. Mabyn and St. Tudy a higher angle brings up the blue, purple, green, and grey slates, which range continuously from thence by Endellion, St. Minver, and St. Enodock, in a thick zone, to the north and west of Padstow.

No. 1, the Tintagel or Clymenien killas, is of perfectly unique mineral type, and a certain proportion of its fossils are as yet equally appropriate and characteristic: it is almost uniformly a delicate pale green, or greenish-grey slate, rarely a bluish-grey, with quartz veins, commonly crystalline—sometimes highly so: it is more or less calcareous throughout; but its nether division, from Tavistock on the east, to Trevalga and Tintagel on the west, contains masses of varying dimensions—oftentimes continuous for many miles together—of a highly calcareous hornblendic and chloritic volcanic ash, which, on decomposing, always constitutes a fertile soil; and at Bradstone, Kelly, Milton Abbot, Lamerton, and on

the north of Tavistock, affords some of the richest land in England.

That it forms the basis and supports the great killas superstructure, is abundantly shown by explicit sections on either side the Tamar—at inland quarries and cuttings, and on the westward coast on the south of Port Isaac, where it passes insensibly into No. 2 by neutral and alternating beds, and indisputably underlies it.

It yields tin and copper near Tavistock and Callington, and lead and silver are worked in it to a greater extent than in either of the killas series above it; excellent roofing-slates are also quarried in it at Tintagel and Delabole on the west, and at Mill-hill, near Tavistock, on the east, and they have also been proved at several intermediate points.

It passes into great lentiform bunches of lime-rock at Trenalt and Petherwin, near Launceston, which rests on, and are parted by, black anthracitic slates, with thin layers of culm, identical with such as are seen in the subjacent carbonaceous rocks: these limestones to the eastward gradually thin out to nothing, by irregular seams and flat insulated cakes, among true killas slates; but their earliest introduction is manifestly by thin calcareous courses containing the characteristic Petherwin fossils, among the underlying carbonaceous rocks, as may be seen south of Landue Mill, near Launceston: these limestones and associated slates are at times as abundantly loaded with the remains of ancient life as any of the secondary rocks. I have seen, in short, masses of lime-rock which decomposition showed to be concretionary aggregates of organic structure: of these I have been fortunate enough to obtain a very large and varied assortment, many of them as yet undescribed; among other large specimens of the beautiful *clymenia*, I have one which is nine inches in diameter.

This lowest member of the killas group does not appear at all on either the east or the south of Dartmoor, and is first met with on the south-west of it, a little north of Borringdon Wood, from which its southern line is of course the north one of No. 2, already described, as far as a little south of St. Ive, from whence it mantles round the inner zone of carbonaceous rocks (which closely invest the Bodmin Moor granite on the north and north-west as far as near Michaelstow, on the S.S.W. of Camelford), beyond which, falling

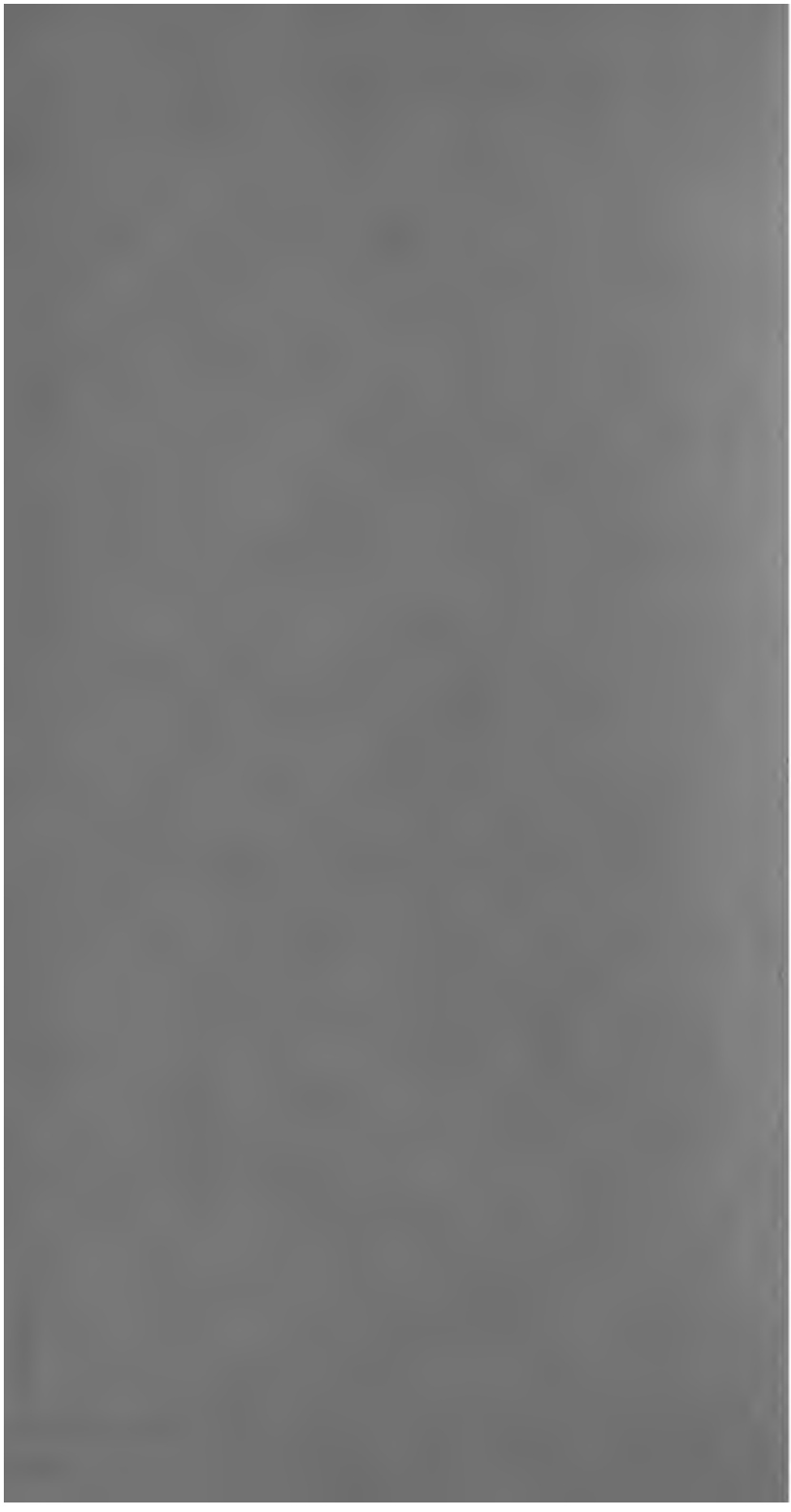
in again with No. 2, it accompanies it to the sea on the south of Port Isaac, as before adverted to, and does not appear afterwards in any of the southern sections, a circumstance which, coupled with the interposition of No. 2 along the Padstow estuary and to the eastward of it, proves that the fossiliferous beds of Petherwin are not conveyed to St. Columb-Porth, Newquay, &c., as has commonly been supposed.

The accumulated evidences of its superposition, with regard to the plant or carbonaceous rocks, are so strong, that any attentive observer must admit that this series overlies and passes downwards into them, by far more abundant and conclusive instances of simple section, gradation, and alternation, than even those carbonaceous rocks present on the north of Devon, where they are now admitted on all hands to pass by insensible transition into the older group of Exmoor: the evidences of the former are certainly far more abundant and demonstrable than anything of the kind I have ever met with elsewhere, but exhibited at times on so vast a scale, that the fidelity of their details is apt to be overlooked in the magnitude of their proportions: in one instance, for example, on the west bank of the Tamar, a traverse of six miles of country; viz., from about two miles east of Petherwin to South Hill, near Callington, displays nothing but neutral beds, or interchanges, or interlockings, of killas and carbonaceous rocks, or of carbonaceous rocks, fracturing and piercing through the killas, prior to the latter overwhelming them by its enormous accumulations.

The Boscastle sections however, on the other hand, are so readily comprehensible and simple, as scarcely to admit a doubt of it, corroborated as they are by the coast cliffs to Tintagel, where the anthracitic schists, which are seen in mass at Boscastle supporting the killas in almost a tubular form, are observed to be continued upwards among the pale green roofing-slates by repeated interpolations, of which ready examples may be seen close by the church at Trevalga, a little farther south, at Treworthal.

Such are the natural subdivisions of the great killas group, founded on peculiarly-appropriate types and continuity of series, guided by, which I trust I have sufficiently shown that I have relied on, or misled by, nothing which was arbitrary or inconstant.

Its position as the crowning extremity of a magnificent, consecutive, and abundantly-varied series (as yet unrivalled by any hitherto developed by rigid and direct analysis), I have endeavoured to show as clearly and in as much detail as the nature of the communication admits, and so far its place in the European system may be determined and mapped down with certainty, if it shall eventually be shown, as I confidently anticipate it will be, that I have been correct in my views, that the entire Devonian and Cornish group is based on (probably the upper beds of) the old red sandstone.



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